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The Institute of Vitreous Enamellers
The National Ironfounding Employers' Federation
The Welsh Engineers' and Founders' Association
and
The Foundry Trades' Equipment and Supplies Association

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An American Grey Iron Castings Specification

The classification "light grey iron castings" constitutes a very large proportion of the total production of the whole foundry trade, and for this reason any specification dealing with this class of foundry goods is clearly of first importance. For specification purposes the phrase "light grey iron castings" must be held to cover the wide variety of small castings not catered for by any particular special purpose specification. Where special specifications exist for such light castings as rain-water goods, stove-grate parts, internal-combustion engine valve-guides and the like, such castings could not be regarded as coming within the ambit of a general specification. There are, however, many light grey iron castings used in machine construction and general hardware purposes for which there exist no special specifications, and it is presumably these that are to be catered for by the new proposed tentative specifications for "light grey iron castings" A 36T issued by the American Society for Testing Materials. Whilst these proposed specifications as reported have been approved in substance by the committee of the A.S.T.M., they are subject to further editorial improvement before publication following acceptance by the Society.

In their scope these specifications are designed to cover light grey iron castings in which appearance, machineability, and dimensional tolerances are primary considerations. They contain no new criteria of standards of appearance or machineability, and the inspection clauses provide for visual inspection for appearance and surface smoothness in comparison with samples accepted as standard. Standards of machineability and tests for this property are left for agreement between the purchaser and manufacturer, and even hardness test requirements are left to the desire and agreement between these two interested parties.

Dimensional tolerances, whilst recognised as one of the primary considerations in the class of casting covered by the specifications, are not provided for in any other manner, and no standards of tolerances are set up. The Grey Iron Division of the American Foundrymen's Association has for some time been engaged in studying this question, and the Sub-Committee of our own Institute of British Foundrymen dealing with this matter were permitted to refer to the tentative proposals of the A.F.A. in this connection, in their report to the Glasgow Conference. It is clear, therefore, that this subject is being studied in America, but evidently they have resisted any temptation they might have had to incorporate any proposals of a quantitative nature in the specification; in fact the whole of the requirements of the specification can be summarised in the words so very familiar to all foundrymen that:—"the castings are to be sound, clean, free from blowholes and defects, and shall be accurately moulded in accordance with the pattern or sample casting submitted."

It is perhaps the two "Notes" which appear in the proposed specifications which will interest a good many foundrymen in this country. The first refers to strength tests, and following the clear statement that strength is not a primary consideration the "Note" reads that:—"*Strength tests should not be specified unless absolutely required*, because as the strength requirements are increased the making of the casting becomes more difficult, as does also the machining of the casting, with the result that costs are increased." The second "Note" appears in connection with machineability and warns us that "There is no definite factor for correlation between physical tests and machineability."

A point of view can be taken that these two "Notes" are the most valuable portion of these proposed tentative specifications. The magnificent technical progress made by cast iron over recent years ought not to make us blind to the fact that this point of view may be perfectly rational.

Country Jobbing-Foundry Adoption

A feature of the post-war activities was the adoption by the large cities of small towns and villages which had been devastated. A visit to the countryside in Great Britain will reveal a large number of tiny foundries owned by real craftsmen whose business has been equally devastated by the subsequent economic war; and for these we plead for a similar adoption scheme by the larger foundry establishments and combines. We plead for their continuance as an entity in the industrial system, because they provide the finest training grounds for craftsmen and executives. It has been well said that apprentices in the larger foundries never hear anything which will be to their advantage during the dinner hour. In the small country foundry there usually is ample time to go to home or lodgings. We

have recently interviewed several owners of these small concerns and they say that they do not make much more than the mechanic's weekly wage, but there is an obvious desire to keep alive an old family business. These men are proud and would refuse charity in the usual interpretation of the word. The placing of orders with them, coupled with a close paternal interest in works organisation and costing, would do much to make them regain a live interest in their work. Such foundries as those we have in mind generally have a fair standby in the shape of orders for plough shares. They also realise that they require a few pieces of simple foundry machinery, such as sand-preparing plant and lifting mechanisms. Quite often such plant could be obtained through the adopting firm. There is no suggestion that a financial interest should be taken in these small concerns, but that they should be "nursed." A youth of average intelligence would obtain a real general knowledge of every aspect of foundry practice except those peculiarly to be associated with quantity production.

The establishment of really friendly relations between the very largest and the very smallest foundries would go far towards the elimination of insensate price-cutting; to the welding of the industry into one homogeneous unit; to the creation of really skilled craftsmen for the future conduct of the industry, and to the technical enlightenment of the small foundry owner, associated with an appreciation of his undoubted difficulties by his larger and more successful colleagues.

Iron and Steel Works in Mexico

In his Report* on "Economic Conditions in Mexico, March, 1936," issued by the Department of Overseas Trade, Mr. J. Pyke, H.M. Consul-General, Mexico City, points out that iron and steel are of importance in Mexico's economy and the industry has enjoyed a period of marked activity. Excluding the Government arsenal, which has produced ploughs for agrarians and smallholders to the order of the National Agricultural Bank and numerous small ironfoundries and nail factories scattered throughout the country, the annual output from the three leading works, with sales in 1935 estimated at 30 million pesos (approximately £1,667,000 at current rates), averages about 160,000 tons of rails (14 to 90 lbs. per yd.), structural steel, reinforcing rods, wire, nuts and bolts.

The largest works, situated at Monterrey, representing 60 to 70 per cent. of the total investment in the industry, has paid monthly dividends throughout 1935, and is about to invest a million pesos in extensions to buildings, the construction of furnaces, travelling cranes, turbines, etc.; it obtains most of its raw material from the Cerro Mercado in Durango, one of the geological wonders of the world, which is estimated to contain 100 million tons of hematite ore, with an average content of 65 per cent. Monterrey annual production, averaging 110,000 tons, is by the open-hearth process with natural gas at present piped from the U.S.A. It has the only blast furnace in the Mexican Republic with a rated capacity of 350 tons per 24 hrs.

The other two important concerns are in Mexico City, and work with purchased electric power, the larger operating three electric furnaces and producing most of the steel castings. Recent developments and projects include a copper wire-drawing and cable-making plant, and electrodes in the larger factory of the federal district, and barbed wire at Monterrey.

* No. 642. H.M. Stationery Office, Adastral House, Kingsway, London, W.C.2. (Price 1s. net.)

The New Wear Forge

The New Wear Forge was one of the earliest units of the British iron and steel industry. It was erected by George White, then of Monmouth Forge, in conjunction with Anthony Grubb, in 1684, and successfully carried on for many years by his son, also George White. In 1695, the works are thus described in an old paper:—

"The Earl of Kent, upon an old foundation, has lately built his forge, which is one of the best in England, having two hammers and three Chaferies or Fineries, which can work in the driest time of summer. There are besides, a dwelling house for a tenant, stables, warehouses, and outhouses, and several dwelling houses lately built for above 30 families, costing together about £4,000."

A daughter of the old George White married a Mr. Jordan, ironmaster of Tinterne, in 1690 or thereabouts. George White, the son, succeeded George White, the father, and the works still prospering, the son had built himself, in 1739, a comfortable mansion at Goodrich.

In 1753, George White (the son) retired from the business and granted a lease of 14 years of:—

"The Wear, Lock, Forge, Fishing, Dwelling House, Slitting Mill, Storehouses, and including the royalty on fishing, at the yearly rent of £270, and £10 to be paid to the Lock-keeper, to John Partridge, Ironmonger, of Ross."

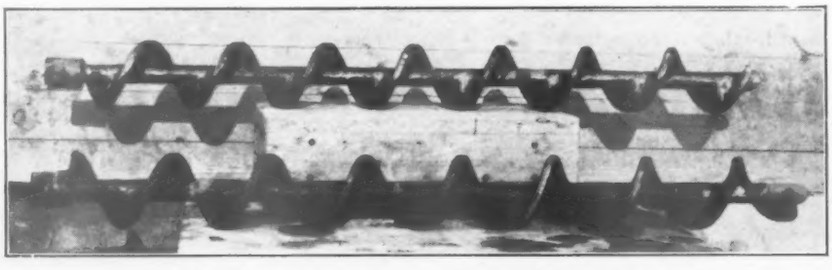
There is a special covenant as to the fishing, to this effect:—

"If, after paying all expenses of managing the fishery, the neat produce should exceed £30, then of all such excess one-third is to be paid annually to Mr. White, and Mr. Partridge undertook to send him annually 'a true and just account.'"

The works seem to have consisted solely of fineries and puddling mills for turning out manufactured iron in the state of sheet and rod iron. The pigs were brought from Tinterne by the river, and from Carmarthen by vessel to Llandogo, thence by barge. Coal was brought from Lydbrook by barge. A large quantity of salmon was caught some years, and Mr. Partridge is reported to have jokingly said: "The Fishery paid better than the Forge."—"Bradley's Magazine."

Nickel-Chromium-Molybdenum Cast-Steel Screw

The accompanying illustration shows a conveyor feed screw made in nickel-chrome-molybdenum cast steel which was recently cast at the Stockton steel foundry of Messrs. Head, Wrightson & Company, Limited. The casting is a special screw and measures 5 ft. long by 5 in. overall diameter of the screw. This type of steel combines high tensile strength and toughness with a great resistance to wear.



Nickel-Chromium-Molybdenum Cast-Steel Screw.

Income Tax Codification Committee

The Federation of British Industries last Saturday submitted to the Chancellor of the Exchequer its views upon the Report and Draft Bill prepared by the Income Tax Codification Committee. The Special Committee of the Federation, which has made a careful examination of the Report and Draft Bill, records at the outset its profound admiration of the thoroughness and ingenuity which, notwithstanding the regrettable restriction of their terms of reference, have enabled the Codification Committee to produce such an admirable result.

The Federation desires to express its approval of the scheme and arrangement of the Draft Bill, and would strongly urge that an Income Tax Bill following the general lines of the Draft Bill should be laid before Parliament at an early date after due consideration of the various points brought forward by the Federation.

From the Federation's point of view, one of the most important innovations of the Draft Bill is the proposed method of dealing with wear and tear allowance. The proposal is that instead of these allowances being treated as a relief from the assessment, they should be made a business charge in the year in which the depreciation takes place. Provision is made whereby the present advantage of carrying forward wear and tear allowances indefinitely would not be interfered with in the event of there being insufficient profits within six years to absorb losses. It is noted that the machinery to determine the deduction allowed for wear and tear set out in Rule 6 of the rules applicable to cases (i) and (ii), Schedule D, finds no place in the Draft Bill. It may well be that this omission was deliberate on the general ground outlined in the Report that allowable charges against profits for income tax purposes should be based on commercial practice, and with this in view and the ordinary procedure of appeal, the position is regarded as satisfactory by the Federation.

Catalogue Received

Electric Furnaces. The present—and very advanced—state of the science of electric-resistance furnaces is well disclosed in a new pamphlet just issued by Wild Barfield Electric Furnaces, Limited, and G.W.B. Electric Furnaces, Limited, of North Road, Holloway, London, N.7. The type described incorporates the "Heavy Hairpin" heating elements. The brochure is well illustrated, and includes a number of foundry applications, such as vitreous enamelling and hardening cylinder liners. In this modern design the plant is virtually automatic in respect to both temperature and atmosphere control. Whilst the life of the heating elements has been materially improved in recent years, so that it now no longer is a problem, yet attention is given to their easy replacement. The brochure is available to our readers on request.

Symposium on Cast Iron

NOVEL DEVELOPMENTS DISCUSSED AT EDINBURGH

The recent Annual Conference in Scotland of the Institute of British Foundrymen included a technical session, held in the Heriot-Watt College, Edinburgh, which took the form of a symposium on cast iron.

The President (Mr. Harry Winterton) presided, and introduced the members to Dr. Smail, Principal of the Heriot-Watt College, who welcomed them very heartily to the College and to Edinburgh.

The symposium included the presentation of four Papers dealing with various aspects of cast iron, namely: "The Fracture of Pig-iron and Cast Iron," by Dr. A. L. Norbury and E. Morgan, B.Sc. (see FOUNDRY TRADE JOURNAL, June 11, 1936); "The Founding of Pressure Castings," by H. H. Judson (New York) (FOUNDRY TRADE JOURNAL, July 2); "The Influence of Wall-Thickness on the Mechanical Properties of Cast Iron," by Dr. H. Jungbluth (Essen), (FOUNDRY TRADE JOURNAL, July 9 and 16); and "A Study of the Influence of Manganese and Molybdenum Additions to Cast Iron," by J. E. Hurst (Immediate Past-President) (FOUNDRY TRADE JOURNAL, July 16 and 23).

The Two-Cupola Method

MR. F. J. COOK, referring to Mr. Judson's Paper, said the question of what he ventured to think was a kind of inoculation was, to his mind, a most interesting subject. He was familiar with a foundry in this country which had been doing similar work for a long time, but from rather a different angle. This foundry was casting throughout the day, and the general run of the work was two mixtures, one of which was white iron, and the other consisted of one grey iron composition for general work. It also happened that there was a fair amount of high-pressure work in the way of cylinders, which was a nuisance to produce, because it affected the regular run of those two classes of metal. As a result the foundry manager had worked out the percentages of the white and soft irons to produce the analysis required for the cylinders; when he tried it out, to his amazement the cylinders produced were very much superior. They were free from shrinkage troubles, and well withstood the pressure tests, whilst the general structure and machineability were much improved. That practice had been continuing for a very long time. Very much superior results were obtained in this way than by producing castings of the same composition, made up of a mixture practically to the same analysis. Ironfounders were generally recommended in this country not to mix white and grey irons, but in mixing them in this way—melting them separately and mixing them—there was a remarkable improvement in structure. Personally he had been intrigued with this, but he could not fathom it, and this Paper did not help him to understand what actually took place, and why these good results should obtain. If the author could throw any light on the problem he would be helping them along the road.

MR. JUDSON, in reply, remarked that two years ago they had had a Paper on the subject in New York, and that very question was asked by himself. Incidentally, they tried several times to run the mixture through one cupola, and they did not get the same result at all. They would have a sweating at 3,000 or 4,000 lbs. pressure test. He thought that, probably, if they could get the soft iron addition in the chilled form, that was, chilled forcibly, they might be able to get somewhere.

Molybdenum and Manganese Additions

DR. ARTHUR B. EVEREST (Mond Nickel Company, Limited), dealing with Mr. Hurst's Paper, remarked that, in his opinion, the Paper was a very valuable addition to the literature on the subject of alloy cast irons. Dr. Everest went on to remark that he was somewhat puzzled at the choice of the alloy combination which Mr. Hurst had made, since, generally speaking, when two additions were made to cast iron, they were chosen so that they balanced one another in respect to their effect on chill. In the present instance, however, both manganese and molybdenum acted in the same direction in increasing chill, and no claim could be made to the effect that this was a balanced addition. This led naturally to the result that, when manganese and molybdenum additions were made, the castings tended to become white, and it would seem that the interest of the material lay rather in its properties after a subsequent graphitising anneal, the necessity for which, of course, rendered the combination of doubtful general utility.

Roll Practice

Dr. Everest stated that Mr. Hurst claimed very high hardnesses for white irons with martensitic structures produced by the alloy additions. He would be interested to know whether these irons had any special advantage over the well-known "Ni-Hard," which was produced by adding nickel and chromium to a white iron. The structure and hardness in "Ni-Hard" was very similar to that shown in the present series, and it would be of interest to know, therefore, whether any special advantage could be claimed for the hard iron produced with manganese and molybdenum. He thought it of interest to mention in this connection that, in "Ni-Hard" rolls, proportions of molybdenum were frequently used, and also as a result of research work in the United States it was becoming the practice to increase manganese to abnormally high levels. It would thus appear that in the latest type of "Ni-Hard" rolls full advantages of the nickel-chromium and also of the manganese-molybdenum additions were being achieved.

A point which appeared to be of some interest was mentioned about the middle of the Paper, where it was pointed out that, in spite of the relatively high hardness of these alloy irons, they showed in the ring-test less internal stress than normal. Dr. Everest inquired whether this did not appear to some extent to be contradictory, since one would normally expect high internal stress to be associated with hardness. Did the explanation in the present case lie in the heat-treatment?

The Star Test

One other point that interested the speaker very much was the star test, which Mr. Hurst showed in Fig. 1 of the Paper. He (Mr. Everest) believed that this test originated in the works of the Midland Motor Cylinder Company, and it had been used by himself in some of his early work on aluminium in cast iron. This had been developed for a specific purpose, and, although satisfactory as a check on automobile irons, he had abandoned the test as not being generally applicable to all irons. He would therefore be interested to hear why Mr. Hurst had adopted this test now in connection with his present work.

Two-Cupola Iron

Commenting upon Mr. Judson's Paper, Dr. Everest remarked that Mr. Judson said he cast the metal as soon as possible. This was a point of particular interest, in view of the question of the relationship between the time factor and inoculation. He stated that he would like to know whether Mr. Judson found a change in the form of the carbon resulting from holding the metal for any length of time or whether the precaution of casting quickly was merely to ensure as high a casting temperature as possible.

Section Sensitivity

MR. G. L. HARBACH (Newark), dealing with Dr. Jungbluth's Paper, remarked that having himself written a Paper on a similar subject, he had read Dr. Jungbluth's contribution with great interest and had found it very informative. There were, however, one or two points that he would like to emphasise. Early in the Paper it was stated, quoting M. v. Schwarz and A. Vath, that under certain conditions satisfactory agreement between the strength of a casting as a whole and that of a test bar could be obtained if the diameter of the bar were made twice the wall thickness under test. Later on in the Paper, however, Dr. Jungbluth showed that the sensitivity was much less, and in fact he quoted a 30-mm. bar as having the same strength as 30 mm. in the casting. That supported the results of his own work and confirmed the fact that sensitivity to section thickness varied considerably with the quality of the iron, so that that particular reference to the diameter of a bar being twice the thickness of the section to be represented could only be applicable under certain conditions, and those conditions would have to be very closely controlled. Then, quoting Coyle's work, Dr. Jungbluth had stated that the percentage diminution in strength was equal for each grade of cast iron. The remainder of the Paper and personal experience certainly suggested that that was not the case.

Mention of hardness as related to tensile strength made him feel that was going a little far, except again under very controlled conditions. To talk in terms of percentage of increase in Brinell hardness in relation to percentage increase in tensile strength was not to his mind correct, because the Brinell hardness did not necessarily vary consistently with the tensile strength. It was possible to produce a low-carbon iron of 24 tons tensile strength with a Brinell hardness of 250 and a low-silicon iron of 14 tons tensile also with a Brinell of 250. Moreover, the high-test iron would machine readily, whilst the low-silicon iron would only be machinable with difficulty. From this it was obvious that the Brinell hardness of different types of iron had no real relationship to tensile strength, neither was it a measure of machining hardness of cast irons. Mr. Harbach concluded his remarks on Dr. Jungbluth's Paper with the observation that the author was to be congratulated for his Paper undoubtedly covered a very wide field, and was in his opinion a valuable contribution to the subject.

A New Specification and Two-Cupola Iron

Mr. Harbach also made some observations on Mr. Judson's Paper. He remarked that, being in the same line of business and having used irons similar to those mentioned, he had read Mr. Judson's Paper with great interest. The classification of the two types of cast iron—structural and pressure—and their respective requirements was welcome, particularly in view of the fact that a new specification for high-duty cast iron would shortly be issued in this country, and it was very desirable that the high-test irons should be used in a reasonable manner. Once it was accepted that the usual textbook quotation of 10 tons tensile strength was low, there was a danger that the high-strength irons might be adopted as standard and specified for all types of castings, including those in which mass rather than strength was the deciding factor. Such a position would prove a great disadvantage in foundries. A clear distinction between the two classes of cast iron, and the rational use of the high-strength irons was necessary, for the development of the technique for handling low-carbon irons was essential and was often an expensive business when changing over from the production of ordinary irons.

Turning to the mixtures used, Mr. Harbach said it would be interesting to know what was

the composition of the steel used, as the analysis of the metal from the 86 per cent. steel mixture suggested a high silicon content in the steel and a low manganese content, or a high loss of manganese in melting. From the fact that all the high-duty irons carried no scrap returns, it would appear that either the pig-scrap mixture was over 50 per cent. scrap or the tonnage of bedplates and frames, etc., exceeded half the total output. Had Mr. Judson used the return scrap from high steel mixtures in the same mixture? It seemed a pity that such good scrap should be used in common iron, as it would obviate the expense of duplexing to raise the total carbon—as indicated quite early in the Paper, a single cupola was capable of meeting the requirements—and enable the common iron to be run with a higher phosphorus.

The high steel-mix iron with 2.4 per cent. total carbon and 1.35 per cent. silicon would certainly require some adjustment, and it matched personal experience with a similar mixture. Further to this, it was often difficult to obtain a sufficiently high carbon from a high steel mix without scrap in the charge—holding the liquid metal in the cupola had little, if any, effect on the carbon—and the silicon was rarely over 2 per cent. as tapped, even if 3 per cent. was charged.

Nickel Additions Advocated for High-Duty Irons

Increasing silicon had little compensating effect for low carbon around 2.5 per cent., and it had been found that, with a carbon of 2.6 per cent., raising the silicon from 2 to 3.5 per cent. had little effect on the tensile strength, it being about 24 tons throughout. Regarding the difficulty of using low-carbon irons, as far as possible it was advisable to make full use of irons with 3 per cent. or more carbon, and, when a low-carbon iron became necessary, the highest carbon compatible with the strength required should be used. In this respect the use of nickel was often worth while, as higher carbons might be used for the same strength, thus simplifying foundry operations and giving more consistent results. The mixed metal quoted by Mr. Judson (2.5 to 2.65 per cent. T.C and 1.5 to 1.7 per cent. Si) would personally be considered so near the border line that erratic results would be expected in the foundry machine shop and strengths and fractures of test bars, and the low limits quoted of 2.4 per cent. T.C and 1.5 per cent. Si much lower than necessary for an iron around 20 tons tensile. It would be expected that an inoculated cast iron (with or without nickel) carrying its own scrap returns, with 2.8 to 3 per cent. T.C, would give the strength required with improved casting properties, and probably save the extra cost of nickel, if used, by preventing waster castings.

Cost of Low-Phosphorus Castings

With regard to the soft iron mentioned in the Paper, containing 0.25 to 0.45 per cent. P, and used "where ease of machining is a vital factor," it was a matter of some interest, and he would be glad to know whether the phosphorus was kept low deliberately with a view to assisting machining. Whilst the general view was that phosphorus acted as a hardener, and, therefore, was detrimental to machining, his own view was that, up to 1 per cent., it acted to some extent as a graphitiser, and, also, by lowering the strength and toughness of the iron due to the presence of phosphide eutectic in the structure, the general effect of phosphorus was one of embrittlement which improved rather than detracted from the machining properties. This particular point might be out of the scope of the present Paper, as it dealt essentially with high-duty irons, but it was of importance to the manufacturers of small and non-pressure castings from the financial viewpoint. In this country the reduction of phosphorus cost about 1s. per ton for each 0.1 per cent., so that soft 0.3 per cent. phosphorus iron without steel was roughly 7s. a ton dearer than a 1 per cent. phosphorus mixture. This made a big difference in total metal cost, as over half the output was likely to be in this class of iron. In conclusion, Mr. Harbach said he wished to thank Mr. Judson for a very interesting and informative Paper.

Fracture of Pig-Iron

MR. J. G. PEARCE (Birmingham) said he wished to emphasise a few of the points dealt with by Dr. Norbury in his admirable Paper. Constancy of fracture did not mean, and never had meant, constancy of silicon content. This was well brought out in the Paper. Some writers had made great play with silicon variations for the same fracture and used them to condemn fracture, but, as was shown in the Paper, if the carbon varied in sympathy the chilling properties remained the same, which was what the founder was interested in. Some countries had completely abandoned fracture as a guide for classifying or purchasing pig-iron. Dr. Norbury's Paper showed that the British feeling that fracture did mean something had a scientific justification. It told the ironfounder something not necessarily gleaned from analysis, but it had to be added that pig-iron could not be purchased on a specification including both analysis and fracture unless it was specially selected. The blast furnace could not be controlled to give both.

Another point was the remarkable way pig-iron compositions followed the eutectic line, and the closeness to it of the most widely used foundry iron, No. 3.

Titanium Refining Process

Mr. Pearce, continuing, said that the titanium refining process was a remarkable development. Nobody had produced such uniformly fine graphite in such sections and with such high carbons. It was a development, however, which at this stage should be regarded as a fundamental investigation into the cause and mechanism of graphite formation rather than as a process, although the possibilities of application were, of course, not being overlooked. If further investigation confirmed that coarse graphite arose from the presence of silicate slag, and that fine graphite was formed when this slag was either absent or prevented from acting in a usual way (as in the titanium process), the greatest single step forward would have been taken in the understanding, and hence in the control, of graphite formation, which meant the control of properties. It looked as if fine graphite was the normal condition of cast iron, and that in a sense coarse graphite was the exception, due to the universal use of silicon in pig and cast iron. Of course, many other possible methods of achieving the fine graphite had been examined. Mr. Pearce remarked that to a body containing those interested in the aluminium alloys and their modification there was interest in the remarkable similarity between these structural changes in cast iron and those occurring in the modification of the aluminium alloys. So much was this so that we spoke of the cast iron as "modified" when it underwent this change, and as "demodified" when the reverse was effected. The explanation in all probability was on similar lines for both metals, and, indeed, it might be said that the main problem facing all metallurgists on cast alloys—cast iron, steel, non-ferrous—was that of the non-metallic inclusion, and investigation on these lines would have far-reaching effects.

An Ideal Exchange Paper

Commenting upon Dr. Jungbluth's Paper, Mr. Pearce remarked that, in his opinion, it formed an ideal exchange Paper, because it presented developments in the author's country over a period of years in a field with which the author was familiar and in which he himself was a distinguished worker. He thought they were very fortunate in having this Paper from Dr. Jungbluth. In this country the effect of what in Germany was called wall-thickness sensitivity had, of course, been recognised, and the effects of section, composition and alloy additions had been studied, but not to the extent they had been studied in Germany. The reason for this, he thought, was that British investigators were more concerned with the practical than with the theoretical aspects of the question, and while we could whole-heartedly agree that there was a general law, such as that given early in the Paper, it seemed that the variations in composition and graphite size which were obtainable in practice were so wide that each cast had its own constant c and exponent m, and that it would be dangerous to attempt to predict sensitivity from formulæ derived from tests on one material applied to another, even of similar composition. Also the moulding, casting and melting conditions had to be considered, as was pointed out by Dr. Jungbluth.

Brinell Test and Tensile Ratios

Perhaps this point could be illustrated by saying that various Continental writers had suggested a connection (given in a specific formula) between Brinell hardness and tensile strength. These formulæ, of course, differed from each other, and clearly could not all be true, or true of all cast irons. They were true for the particular compositions studied, for the conditions under which the test was made. We therefore said that there was no general connection between Brinell hardness and tensile strength, but that a connection found between these properties for a given composition and thickness might remain true for the same material made in the same way.

The difficulty of formulating these general connections was abundantly shown in Dr. Jungbluth's Paper, and there was cause for congratulation in that he had made no attempt to shirk or minimise the difficulties. The difficulty of drawing curves to fit points in Figs. 6, 7, 8 and 9 was evident. Dr. Jungbluth concluded that the work on alloy irons was calculated to give qualitative results only, and data on castings were meagre, while the relationship between the mechanical properties of wall thickness in castings and test bars was still obscure. If this was the result of the volume of work embodied in the present review, how much more remained to be done? The speaker had been struck many times with the number of curves of a kind which lent themselves to logarithmic treatment and hence provided a mathematical relation between the quantities concerned, but treatment on these lines had shown the results to be too scattered to permit a relation to be formulated, even for one material. Such curves had been given in Papers to the Institute of British Foundrymen and elsewhere, and connected, for example, cast section size and any mechanical test, such as transverse strength, tensile strength, torsional strength, hardness, and also deflection and elastic modulus. Perhaps less erratic results would come out of the application of tests to irons containing completely refined graphite, as described in a parallel Paper by Dr. Norbury. Mr. Pearce concluded with the remark that some work on the connection between test bar and casting was also in progress.

Tensile Test and Casting Thickness

MR. C. E. WILLIAMS (Past-President) said he would like first of all to thank the authors of the Papers for the Papers themselves, especially their friend from Germany and their friend from the United States, for coming such a long way to present their admirable Papers to the members of the Institute. In the Paper of Dr. Jungbluth Mr. Williams said he was particularly interested in this question of wall thickness. Recently his own firm had some castings weighing 3, 4 or 5 tons, of a thickness of at least 6 in., and they had to cast on to them tensile test pieces. They had had much trouble in getting the test pieces—in fact they had a good deal of trouble with the inspector. He would not pause to tell them how they got over that difficulty. (Laughter.) The question he would ask was:

Was there in existence a proper connection between not only the breaking test but the tensile test and the thickness of the casting piece which was being cast? Was there a proper set of data in this country? If not, it was surely a very simple thing for the Institute to take the matter up and look into it, because he could assure them that the specification that came to his firm was impracticable, and it came from one of the largest users of castings in this country. If there were not proper data in this country, he suggested that that was a matter which the Institute could very properly take up.

Mr. A. Sutcliffe (Bolton) asked Dr. Norbury the reason for discrepancies in the analyses of cast iron when received from different centres, and whether a good analysis was a fundamental factor in the making of a sound and satisfactory casting. Other queries related to the ascertainment of the composition of the scrap used in cupola charges; whether satisfactory figures could be obtained from open sand-cast test bars; and if there were factors other than chemical composition which affected the real worth of pig-iron and which were appreciated by the practical man. In connection with this last question he cited the problems of carbon pick-up in the cupola, rapid loss of "life" in the ladle and frothing slags. Finally, he asked—assuming the moulder had made a perfect mould—why the metallurgist should not provide perfect metal which would eliminate any necessity for chills, denseners and nailing.

Mr. Ben Hird mentioned an instance that had come under his own observation bearing on what had been said about the fracture of pig-iron and the resultant fracture in the casting. He admitted that he spoke of a freak batch which had come with a delivery of hematite pig-iron. The fracture was that of a No. 3 hematite iron, tough to break and easy to drill. The graphite showed a peculiar formation like a closed-up star or a daisy. This iron was carefully melted in a clean crucible and poured into a green sand mould containing 1 in. by 1 in. by 14 in. test bars, which were allowed to cool normally; when broken, the fracture was pure white. Another piece of the same pig was melted in the same way and poured into a dry sand mould, containing a 4 in. cube block. When this was split open, the fracture was white at the corners and along the sides, and the remainder deeply mottled white. He thought it would be of interest to the meeting to mention this experience, because it was a very remarkable result to get from what was to all appearances a good No. 3 hematite iron. The compositions of the pig-iron and casting were:—*Pig-iron*: T.C, 3.42; Gr, 2.64; C.C, 0.78; Si, 0.51; Mn, 1.02; S, 0.092; and P, 0.068 per cent. *Test bar*: T.C, 3.294; Gr, 0.034; C.C, 3.26; Si, 0.47; Mn, 0.60; S, 0.082; and P, 0.132 per cent.

Mr. Hird expressed doubt as to the accuracy of the manganese and phosphorus contents in the test bar, as these were checked over with slightly different results, but similar proportions.

Dr. H. A. Nipper (Germany) congratulated Dr. Norbury on his very interesting Paper, and also the Institute and the British Cast Iron Research Association on the valuable work it was doing by its publication of such contributions. He asked Dr. Norbury whether he would offer an explanation of the mechanism of the titanium effect on graphitisation.

A Member asked Mr. Judson if he could give any information upon his cupola practice with reference to mechanical or hand charging. He also felt sure that Mr. Judson must have encountered considerable difficulty in connection with porosity. Mr. Judson did mention that he had to make a special point to utilise the metal as hot as possible, but he did not make any mention of what his temperature actually was.

Mr. J. H. Cooper (Darlington) suggested that their object at such a conference was not so much to criticise any Paper, but to work together as a team and suggest what should be done, and how, to overcome this or that difficulty; if they did that, he thought they would be taking a step in the right direction.

The President (Mr. H. Winterton) said he would like to associate himself particularly with Mr. Cooper's remarks. It was a text which he himself adopted about the year 1907 when he gave his first Paper before the British Foundrymen's Association. He thought it was up to the members of this Institute to collaborate even more together in the future than they had done in the past. As Mr. Cooper had said, they had met not actually to criticise one another's work, except in a manner which would help them all to attain their desired object, and he was quite sure that if they did work together as a team, that object would assuredly be well attained. The President concluded by inviting the authors of the various Papers to reply to the discussion.

AUTHORS' REPLIES

Mr. J. E. Hurst, in replying to the discussion, said with reference to the points raised by Dr. Everest in connection with his Paper that he would like it to be clearly understood that this investigation was undertaken purely for investigation purposes at the outset, and the object of choosing a low-silicon iron was that they were interested in irons that were likely to be white in character. He was unable to draw any comparison between manganese-molybdenum alloy cast irons and the alloys known as "Ni-Hard," but hardness alone was not necessarily the sole criterion of the advantages of an iron of that class. He could imagine that hardness must of necessity be accompanied by good strength properties in all aspects of those strength properties in the commercial application of alloy irons of that type. He could imagine, for example, that it was highly advantageous for irons used in the roll industry, and in other industries where chilled irons were used, that they should possess high resistance to fatigue, and consequently there was a need apparent for the investigation of the properties of all the alloy irons of this type, including "Ni-Hard." He suggested it would be worth while carrying out an investigation extended to alloys of the "Ni-Hard" type. Mr. Hurst went on to say that the internal stress figure was a figure obtained by the measurement of the movement of a test ring when cutting the gap, and it was assumed that it was a revelation of the internal stress that existed in that ring before the gap was cut. It had always been a matter of some astonishment to him that they had movements of such a substantial order in these test rings after treating. These movements mentioned in the Paper were obtained on the test rings in the annealed condition, that was to say, the test rings that had been subjected to an annealing treatment, and they had always been led to understand that such treatments tended to minimise the internal stress. In spite of that, internal stress of quite a substantial order was revealed by these gap movements, and it appeared that that internal stress was minimised by an increase in the manganese-molybdenum content. If these facts should ultimately turn out to be of commercial advantage, then the experiments should prove worth while. In conclusion, Mr. Hurst remarked that Dr. Everest had commented on the star test piece he had used. The reason why he used this form of test piece was that it enabled him to obtain the form of test rings he had used for this particular test.

Dr. Jungbluth indicated that, as his knowledge of the English language was somewhat limited, he proposed to reply to the discussion in writing.

Dr. Norbury, in replying to the discussion, remarked that Mr. Hird had mentioned an interesting case. It was difficult to say what it might be due to without knowing the analysis and other particulars, but he thought it raised the interesting point that one did get peculiar cases arising in a foundry, and if members brought such cases up at these meetings it was calculated to prove very helpful. Dr. Nipper had asked for information on the mechanism of the titanium effect. The titanium slag inclusions could be seen in the microstructure of the metal, and he thought the explanation was that they were still liquid when the graphite solidified, and consequently did not have an inoculating action, and the fine graphite structure resulted. Dr. Norbury went on to remark that in Dr. Jungbluth's Paper the author was investigating how the strength varied from one section of a casting to another. As Dr. Jungbluth pointed out, these variations were not obtained in steels, and were due to variations in the graphite size, and therefore the solution of Dr. Jungbluth's problem was bound up with the solution of the problem of what affected the graphite size.

Mr. Judson, in replying to the discussion on his Paper, said it had been a very great pleasure to him to have been able to make what little contribution he had made. It was particularly pleasing to him, because his father hailed from Bradford. Mr. Judson went on to explain that the term "inoculation" was not used in the Paper, because they did not want to theorise and they did not want to steal anybody else's thunder. He thought the photomicrographs indicated that too long a time could be allowed to elapse between the inoculation and the pouring. He might say that they did not let the soft iron and the hard iron stand mixed any longer than they possibly could. The proportion of high-pressure castings to the remainder of their production was such that the scrap return was very low. Definitely, they felt that they wanted low carbon. In reply to another query, he wished to say that they charged by hand. With regard to the question of porosity, he thought that, if they had it operating under 1,000 lbs. pressure on petrol, it would show it up instantly. The temperature they got at the spout was in the neighbourhood of 1,310 deg. C. actual.

The President, in closing the proceedings, said he thought they would all agree that at this conference some most excellent Papers had been presented, and he proposed a hearty vote of thanks to the authors of the various Papers as well as to the members who had contributed to the discussion.

Company Meetings

Head, Wrightson & Company, Limited, Progress

At the annual meeting of the shareholders of Head, Wrightson & Company, Limited, held at the Teesdale Ironworks, Thornaby, last week, Sir Guy Wrightson, Bart., who presided, remarked that they were employing to-day about 2,000 men. Their oldest activity was iron-founding, and to-day they were one of the largest iron and steel founders in the country. Their two steel foundries were working to capacity, turning out castings for almost every variety of engineering requirement. Last year approximately a fourth of the firm's products were exported. They had started the new financial year with a considerably enhanced order-book, though prices were still lean in many directions. Continuing, the Chairman said he would like to issue a warning on the policy of over-expansion to meet the present increased volume of trade. There was a difference between capital spent for cost reduction and that spent for merely the lure of output.

Broom & Wade, Limited

At an extraordinary meeting of the shareholders of Broom & Wade, Limited, held in London on July 27, it was decided to increase the capital to £265,000 by the creation of 160,000 new ordinary shares of 5s. each. Mr. Harry S. Broom (chairman), in the course of his remarks, pointed out that the increase in capital was in order to acquire the whole of the share capital of B.E.N. Patents, Limited. With regard to the financial aspect, it would be appreciated that for a nominal increase in capital of £40,000 the company would acquire the equivalent of profits which last year amounted to nearly £14,000 after deducting the directors' remuneration and fees.

The International Foundry Congress at Düsseldorf

Arrangements for British Participants

As previously announced, the main meetings of the International Foundry Congress will terminate on Sunday, September 20. Arrangements have been made, however, for members of the Institute of British Foundrymen to leave Düsseldorf on the following Tuesday evening, as this will give an opportunity to attend the principal meetings of the Iron and Steel Institute to those who wish to do so. Those who do not wish to attend these meetings will have these days available for attending the Foundry Exhibition and for personal sightseeing. Furthermore, as these arrangements permit of seven full days' stay in Germany, the party will be able to take advantage of the 60 per cent. reduction of fares on German railways, and this reduction has been taken into account in calculating the fare quoted on the itinerary printed below. Special arrangements can be made for those who wish to return earlier.

Extensions

Extension 1.—At the conclusion of the Congress a sightseeing and industrial tour by motor coach.

Extension 2.—Mr. J. G. Pearce, Director of the British Cast Iron Research Association, is arranging for a party of members to leave London on September 8, and visit certain industrial centres in Switzerland and Germany, arriving in Düsseldorf in time for members to participate in the Foundry Conference.

Currency

Strict regulations are in force in Germany with regard to the import and export of foreign and German currencies. Holders of travellers' cheques are entitled to purchase Reich Marks in the form of cheques, at approximately 22 Rm. to the £, as against approximately 12.50 Rm. to the £ current exchange rate. Such Marks can only be used for travelling, hotel, catering and personal expenses, and the amount obtainable by each traveller at the registered Mark rate of exchange is limited to 50 Rm. per day. Full particulars of the currencies and regulations will be furnished to all who take part in the tour.

How to Book

(*a*) Members desiring to participate in the standard tour or in the standard tour together with Extension 1 (Motor Coach Tour of Germany) should communicate with Thomas Cook & Son, Limited, 77, Market Street, Manchester, 1. (Telephone: Deansgate 3082.)

(*b*) Those wishing to participate in the Pre-Conference Tour of Germany should communicate with Mr. T. Makemson, St. John Street Chambers, Deansgate, Manchester, 3, who will make the necessary arrangements with Mr. J. G. Pearce, Director of the British Cast Iron Research Association.

Passports are necessary, which must be up to date and endorsed for Germany, but no special visas are required. The demand for hotel accommodation in Düsseldorf during the period of the Conference is heavy; the Institute has, however, reserved a number of single and double rooms at the Hotel Germania, and application at the earliest possible date is advised.

Itinerary

The programme of the Conference and the Itinerary arranged for the British party is subject to slight modification.

Monday, September 14.—Depart London (Liverpool Street Station), 20.30. Depart Harwich (Parkeston Quay), 22.00.

Tuesday, September 15.—Arrive Hook of Holland, 6.00. Depart Hook of Holland, 6.58. Arrive Düsseldorf (Hbf.), 11.34.

Wednesday, September 16.—Opening of International Foundry Congress. Opening of International Foundry Exhibition.

Thursday, September 17, *to Sunday, September* 20, *inclusive*.—Meetings of the Conference, Works Visits, Social Functions, and International Foundry Exhibition. A detailed programme will be available in the near future.

Monday, September 21.—Meetings of the Iron and Steel Institute.

Tuesday, September 22.—Morning: Meetings of the Iron and Steel Institute. Afternoon: Depart Düsseldorf (Hbf.), 17.45. Arrive Hook of Holland, 23.00. Depart Hook of Holland, 23.45.

Wednesday, September 23.—Arrive Harwich (Parkeston Quay), 6.15. Arrive London (Liverpool Street Station), 8.38.

Fares

The inclusive fare is £10 1s. each, subject to a minimum of 15 persons travelling together on the outward journey. The fare includes travel tickets (London, Düsseldorf and return to London), second-class railway, first-class steamer. Meals *en route*, breakfast on the outward journey and dinner and breakfast on the homeward journey, with gratuities to waiters. Accommodation at the Hotel Germania, Düsseldorf, consisting of bedroom and plain breakfast only, with gratuities. Transfer of baggage only on arrival and departure Düsseldorf. Express train supplements in Germany. Reserved train accommodation minimum rate berth on the North Sea steamers.

Supplementary Charges.—First class travel tickets throughout, £1 10s.

Steamer Accommodation.—The fare provides for accommodation in double cabins. Superior accommodation in double and single cabins can be reserved on the North Sea steamers on payment of a supplement, according to location.

Important Regulations.—The following information must be supplied at the time of booking: name, address, profession or occupation, passport number and where issued.

The above arrangements provide for breakfast only in Düsseldorf as it is found that members usually prefer to make their own arrangements for other meals, and it is expected that some of these meals will take the form of social functions arranged in connection with the Congress.

Baggage.—The fare includes transfer of baggage on arrival and departure at Düsseldorf, but not at the ports, *i.e.*, Harwich and Hook of Holland, as it is found that passengers prefer to see to their own luggage at the ports.

Social Functions in Connection with the Congress

Full details of all these functions will be published later.

Extension 1.—Those taking part in the motor-coach tour of Germany will travel in two parties, which will leave Düsseldorf respectively on September 22 and 23. The route will be via Cologne, Dillenburg, Assmannshausen, Mannheim, Stuttgart, Augsburg, Munich, Nuremburg, Dresden, Berlin. The complete fare from Düsseldorf to Berlin up to and including breakfast and luncheon on Wednesday, October 7, will be 268 Rm. (about £13). Details of this have already been presented.

Additionally, there will be expenses for any extended time which is spent in Berlin, and cost of return from Berlin to Düsseldorf, or neighbouring station, from which point members will continue the journey home, using the return portions of their London-Düsseldorf ticket.

Extension 2.—*Tour arranged by the British Cast Iron Research Association*.—It is expected that the party will leave London on the evening of September 8, and will visit about eight foundries, covering both jobbing and mechanised plants, special alloys, etc., and including the Krupp Foundries at Essen. The party will arrive at Düsseldorf on September 16 in time for the opening of the Foundry Congress and Exhibition.

Congress Notes

Mr. Makemson (Secretary of the Institute) is sending on to those who have intimated their

(*Concluded in next column.*)

A Long-Life Heat-Resisting Casting

For use at high temperatures, one of the most economical materials available appears to be "Cronite"—a heat-resisting nickel-chromium casting alloy. "Cronite" successfully resists distortion, scaling and cracking at constant or fluctuating temperatures up to 1,150 deg. C., and a greatly increased life may be expected from castings in this alloy as compared with cheaper materials such as cast iron. Not only so, but its high tensile strength—considerably greater at

[*By Courtesy of Cronite Foundry Co., Ltd.*

THIS "CRONITE" RETORT HAS GIVEN OVER 12 YEARS' SERVICE AT 1,000 DEG. C. IT HAS BEEN SAWN THROUGH TO SHOW THAT THE WALL IS STILL OF UNIFORM THICKNESS.

1,000 deg. C. than that of cast iron at atmospheric temperature—makes it possible to use castings of thinner section, thereby effecting further economies in fuel and handling costs.

One of many examples of successful uses of "Cronite" castings is shown in the accompanying illustration of a large retort which has given over 12 years' service at 1,000 deg. C. The casting has been sawn through to show that the wall is still of uniform thickness. Cast iron would probably last only six months under the same conditions.—"Nickel Bulletin."

(*Concluded from previous column.*)

interest in the Congress a second circular, which gives additional information.

The American Foundrymen's Association's main party is sailing from New York on August 29, arriving at Cherbourg on September 3. After a week-end in Paris, the visitors are spending from September 8 to 12 in Switzerland, and are making their way to Düsseldorf *via* Heidelberg and the Rhine Valley.

When the Düsseldorf meeting is over the tour takes them to Hamburg *via* Dortmund, Leipzig, Dresden and Berlin. They leave Hamburg on September 30.

A second tour leaves New York on September 6, and this eliminates the Swiss section of the first programme, whilst a third modifies the first programme by including a visit to Le Creusot by shortening the week-end in Paris.

Further details of these American tours—participation in which may be possible—can be had by writing to Mr. V. Delport, the European representative of the A.F.A., at Caxton House, Westminster, London, S.W.1.

Dimensional Tolerances for Castings (With Particular Reference to Malleable Cast Iron)*

By the Sub-Committee of the Technical Committee on Malleable Cast Iron

Introduction

There is no bibliography on the subject of "Tolerances on Dimensions of Castings," and this may be accounted for by the fact that it is only in recent years that the demand for great accuracy in general castings has arisen. During the early part of 1933 the Malleable Sub-Committee in considering their Report[1] and the discussion thereon, presented at the Newcastle Convention, gave some attention to the subject of dimensional tolerances. A brief report was made to the Technical Committee in May, 1933, and further investigation was undertaken and a lengthy report made in December, 1933. At this stage the co-operation of the Steel, Grey Iron and Non-Ferrous Castings Sub-Committees was sought, and experimental work was carried on by members of these Committees throughout 1934, and a further report was made in December of that year. This report has formed the basis for the Paper here presented.

Modern methods of mass-production and machine shop practice, together with the highly competitive spirit which is present in the engineering world to-day, have established a need for greater precision in the making of castings. Difficult situations often now occur between the castings producer and the consumer because of the difference of opinion as to what is a reasonable degree of accuracy. Unfortunately, the question of accuracy to dimensions does not usually arise until after the castings are made and supplied to the customer, when the position naturally becomes very troublesome to both parties.

Machining operations are performed upon castings chiefly to ensure accuracy of dimensions. The machined dimensions given upon drawings always carry a tolerance. This, admittedly, may be small, but it is definitely stated and may be measured during manufacture. The amount of this tolerance is governed by two factors: (*a*) the accuracy necessary for the part to fulfil its function and (*b*) the limitations of the machining equipment which can be utilised. Standard tolerances have been arrived at for the product of the rolling mills, and the figures have been embodied in specifications.

Attention has been given to the permissible variation in dimensions of forgings, most notably by H. Kaessberg,[2] whose recent publication is worthy of close study, as it deals in a most comprehensive manner with the factors affecting variations.

Consideration of existing tolerance specifications upon various products, and such literature as is available, shows that the degree of accuracy specified is within the limitations of the equipment used for economical production. When closer limits are required, it may be possible to employ special technique, but where this is practicable, it will always be at an increased manufacturing cost.

Current Dimensional Clauses

A review of specifications for castings shows that generally the subject of dimensions is dismissed in a clause, the interpretation of which is dependent on individual opinion. The following extracts from existing specifications will demonstrate this.

Specifications for Malleable Cast Iron

B.S.I. 310/1927.—" . . . shall conform as nearly as it is practically possible to the patterns or drawings."

Admiralty, DNC/M/37C., August, 1932.—" The castings are to be to the dimensions specified within reasonable limits. When required, castings must admit of being machined to the exact dimensions stipulated."

Post Office, 75B.—" The dimensions to be in close agreement with those given on the drawing."

British Railway.—" . . . shall be accurately moulded in accordance with the pattern or drawing supplied."

Electrical Firm.—" A variation of $\frac{1}{16}$ in. per ft. from dimensions specified will be the maximum variation allowable."

American Society for Testing Metals, No. A47-T, June, 1932. *Tentative.*—" The castings shall conform substantially to the patterns or drawings furnished by the purchaser, and also to gauges which may be specified in individual cases. The castings shall be made in a workmanlike manner. A variation of $\frac{1}{8}$ in. per ft. will be permitted."

A number of prominent motor vehicle and railway companies do not include a clause relating to dimensions.

Specifications for Grey Cast Iron

B.S.I. 321/1928.—" The castings shall be accurately moulded in accordance with the pattern or working drawings supplied by the engineer."

British Railway.—" . . . to be accurately moulded in accordance with the pattern and/or drawings supplied."

Private Firm.—" All core holes shall be cast true and all unlimited dimensions shown in the drawings must be adhered to within $\frac{1}{64}$ in. (plus or minus)."

Specifications for Steel Castings

B.S.I. 24, *Part* 4, 1930.—" The castings shall be accurately moulded in accordance with the pattern or working drawing supplied by the engineer (or by the purchaser)."

Admiralty.—" The castings are required to conform accurately to the drawings and/or templates. Reasonable local variations of thickness will be permitted at the discretion of the overseer, but a general excess or deficiency of thickness will not be permitted."

British Railway.—" Each casting to be accurately moulded to the pattern supplied with the order by the railway company."

Private Firm.—" All castings shall permit of being machined to the dimensions on the drawings of the parts. The dimensions of parts which are not machined shall be strictly adhered to."

Specifications for Non-Ferrous Castings

British Standards Institution.

B.S.S. 208, 1924. *Special Brass Castings.*—" The dimensions of the castings shall be in accordance with the drawings and all surfaces marked for machining shall have a sufficient allowance for that purpose."

B.S.S. 383, 1930. *Bronze (Gun-Metal Castings, for General Engineering Purposes).*—" The castings shall be made to the dimensions specified and shall be capable of being machined to the finished dimensions. All machined surfaces shall clean up without visual evidence of the cast surface remaining."

B.S.S. 421, 1931. *Phosphor-Bronze Castings for Gear Blanks.*—" The castings shall be made to the dimensions and tolerances specified by the purchaser or to the pattern supplied by him and, after machining, shall be clean, sound, and free from blowholes and other defects. Any casting may be rejected for faults of manufacture, defects, or incorrectness of dimensions, whether discovered during inspection or subsequently during machining, notwithstanding that it has been passed previously as conforming to the analysis and mechanical tests of this specification."

Air Ministry

D.T.D. 264. *Aluminium-Alloy Sand or Die Castings.—D.T.D.* 289. *Magnesium Alloy Castings.*—(3) *Dimensions.* " The castings shall be made to the dimensions specified within the limits given in Clause 4 and shall be capable of being machined where required to the finished dimensions without leaving evidence of the cast surface."

(4) *Margins of Manufacture.* The thickness of castings where not machined shall be not less than the nominal thickness and shall not exceed it by more than 10 per cent. (These clauses are also incorporated in B.S.S. 361, 362 and 363 for aluminium alloys.)

Admiralty Specification.—301, General. The castings are to be sound, clean, free from blow holes, etc. The thickness of the castings will be measured by the overseer, and any material increase of thickness discovered beyond the approved drawing dimensions will render them liable to rejection.

Suggested Improvements

Such phrases as " reasonable limits," " close agreement," " accurately moulded," cannot be translated into definite dimensions, and their meaning must remain a matter of opinion and, unfortunately, a subject for dispute. The limits given in two of the specifications quoted are unsatisfactory, as will be seen later.

It is suggested that the present state of affairs is capable of improvement by some or all of the following methods:—

(*a*) The removal of lax wording from specifications and the substitution of unambiguous phraseology.

(*b*) The publication of defined limits which would form an authoritative reference.

(*c*) The inclusion of such defined limits in the dimensional clauses of specifications.

(*d*) The education of engineers, inspectors and buyers in the operations of casting production whereby they may realise some of the phenomena confronting the founder and gain a more sympathetic outlook.

This Report purposes to show some of the problems with which the founder has to deal, to show how the founder has by experimental work and practical experience endeavoured to cope with these problems, and finally to put forward tentative tolerance proposals which would be suitable for inclusion in specifications, or, preferably at this stage, as would be useful for reference purposes.

Factors Governing the Size of a Casting

The ultimate size of any casting produced from a given pattern is dependent on a wide range of factors, both physical and mechanical. Inherent characteristics of the metal used, physical and metallurgical changes in the metal itself, and many mechanical variables, all help to determine the amount of variation from pattern size shown by the finished casting.

With negligible exceptions both ferrous and non-ferrous metals show contraction on cooling from the molten state to atmospheric temperature. Contraction allowance, therefore, is perhaps the primary consideration when producing castings to meet a definite requirement.

* Report presented at the Annual Conference of the Institute of British Foundrymen in Glasgow.

1 Proc. I.B.F., Vol. XXV.

2 "Metal Treatment," p. 198. Trans. from "Masch.-Betreib. Maschinenbau" (Der Betrieb), No. 10-20, October, 1935.

Contraction

Although slight expansions during cooling may, and do, occur at various critical temperatures in certain metals, these are rarely great enough to balance the contraction which occurs in cooling from the casting temperature, and a casting is, generally speaking, always smaller than the mould in which it was cast. The extent of this contraction has been carefully investigated by foundrymen over a number of years, and it is usually expressed as a linear function. As determined after pouring metal into a mould 12 in. long and $\frac{1}{2}$ in. square, $\frac{3}{4}$ in. square, or 1 in. square cross section, typical contraction constants for a number of the common casting metals may be cited as examples.

Grey-Iron.—High carbon hematite cast iron: 0.140 in. per ft.
Good quality engineering cast iron: 0.158 in. per ft.

Steel.—Light section ($\frac{1}{8}$ in. to $\frac{1}{2}$ in. thick): 0.25 in. to 0.27 in. per ft.
Heavy section: 0.20 in. per ft.

Whiteheart Malleable Cast Iron.—Average hard iron contraction: 0.255 in. per ft.
Average annealed contraction (net): 0.278 in. per ft.

Blackheart Malleable Cast Iron.—Average hard iron contraction: 0.230 in. per ft. (±0.007).
Annealed contraction (net):
Total carbon 2.10 to 2.24 per cent.; average 0.141 in. per ft.
Total carbon 2.54 to 2.84 per cent.; average 0.127 in. per ft.
High temperature—short anneal; average 0.134 in. per ft.
Low temperature—long anneal; average 0.127 in. per ft.

Non-ferrous.—Non-ferrous metals vary considerably, but two extremes may be given:
Monel Metal: 0.25 in. per ft.
White metal: 0.067 in. per ft.

Unfortunately the amount of the contraction becomes inconstant immediately the conditions are changed. The above data refer to castings of standard section and unhindered contraction. If the section of the casting is less, the contraction is usually greater; with greater sections, the contraction is usually less.

Where special conditions intervene, such as heavy cores, or special shapes, a considerable reduction in the contraction is often found. Occasionally no contraction is to be observed, the casting being of the same dimensions as the mould in which it was cast.

A further variable may be introduced by subsequent heat-treatment or annealing, *i.e.*, in the cases of malleable cast iron, steel, certain of the non-ferrous metals, and some special cast irons. Even if there is a complete knowledge on the founder's part of the contraction characteristics of his metal, combined with a wealth of experience on the effects of shape and section upon the contraction, the latter factors will often produce variations which can be remedied only by "trial and error" methods. The location of runners, feeders and chills often have a profound effect upon the ultimate contraction exhibited by the casting.

Variables Introduced by Production Methods

Assuming the contraction allowances made by the founder to be accurate, he is still faced with production difficulties in producing a casting which is "accurate to drawing." The three chief media employed for moulding are green sand, dry sand and loam. Oil sand moulding has some of the characteristics of both green and dry sand. The following remarks and data apply mainly to green sand, though most are equally applicable to dry sand or loam.

Systems of moulding differ chiefly in the method of ramming the sand and working the pattern. Ramming may be by hand with various shaped rammers; by jolting the pattern, moulding box and sand; by squeezing by hand or power; by throwing in the sand from an impeller; or by a combination of these methods. The method chosen depends upon numerous factors, such as the shape and size of the castings, the quantity to be produced, the equipment available and the general economics of the job. These diverse methods are naturally prone to give different strengths to the rammed sand and so affect the contraction by the varying resistance of the mould.

The extraction of the pattern from the mould is another potential source of trouble. Probably the most accurate method is that known as the "stripper." In this case the pattern is part of a rigid machine and works to and fro in guides, often drawing the pattern from the mould through an accurate template or "stripping plate." No rapping or vibration is used to release the pattern from the mould. Since the pattern equipment for stripper work is very expensive, this method of production is only warranted when very high outputs from one pattern are called for.

In other methods, the pattern is mechanically loosened in the mould before withdrawal. This may be performed by hand rapping or by power vibration. Either method results in the mould being enlarged beyond the pattern size, and in the first case this depends entirely on the individual judgment of the operator. The patterns after (or in some cases during) loosening, may be withdrawn by hand, depending entirely on individual skill; or may be stripped mechanically either by drawing the pattern from a stationary mould or by removing the mould from the pattern.

Other parts of moulding equipment have an effect on the accuracy of the mould to the pattern. For example, errors in box joints, pins, snug or dowel holes, etc., all affect the accuracy of the castings produced.

In the case of very straight-sided patterns moulded in strong, smooth sands, there is a constant risk of "ram-offs." This is caused by the ramming pressure of the higher layers of sand forcing the compacted sand away from the pattern at joint level, so forming a mould slightly larger at the joint than was the pattern.

Similar difficulties attend the making of an accurate core. In addition the insertion of the core is an operation attended with some difficulties. The mould must be so designed that the core may be accurately located and held firmly against the tendency of the molten metal to displace it. To ensure accuracy, it is frequently necessary to use gauges when placing the cores, and to prevent subsequent displacement by the use of metal studs, chaplets, or external mechanical means.

In addition to equipment, moulding materials such as sand have a great effect on accuracy. Great efforts are made to obtain uniform mixing from batch to batch, but it is necessary to alter the grade and type of sand used for various castings, and this may introduce variables.

Core sands also present problems, especially dried cores, since these are subject to expansions and contractions during the drying operation. It is frequently difficult to make a core strong enough to withstand handling and erosion by the molten metal, and which will yet yield readily to the contraction of the casting around it.

Apart from errors introduced in the mould itself, dimensional accuracy can be seriously affected by the pouring operation and other details attendant upon it. The mould may be strained, due to pouring too rapidly or to insufficient weighting of the mould. Variation in bulk of metal and its distribution in the mould; the situation of runners, feeders and chills, may all result in dimensional discrepancies by restricting contraction during cooling, or by setting up differential cooling rates in the casting. The "head of metal" initially used in pouring can also produce some variation in dimensions.

Certain of the factors discussed above may result in what might be termed "distortion" of the castings as opposed to ordinary linear discrepancies in size. For example, some castings (flat plates in particular) may show "camber," *i.e.*, a perfectly flat mould may yield a curved or twisted casting due to one face of the casting cooling quicker than the other. Restrained contraction in the mould and differential cooling in various parts of the casting due to any of a large number of causes will often result in serious distortion of the casting.

The "firing" of castings susceptible to cracks (spoked wheels, etc.), or heat treatment of castings, will frequently result in further considerable distortion.

It will be readily appreciated that in spite of all the founder's anticipation and his precautionary measures, there are few castings produced which do not exhibit some dimensional inaccuracy, large or small, attributable to one or more of the above-mentioned factors.

Investigations Carried Out by the Technical Committee

When considering the data set out below, it should be borne in mind that all examples under consideration have been extracted from regular production in foundries, and not from special "laboratory type" tests. Moreover, every casting here considered is giving full satisfaction to customers, the majority of whom have a reputably high standard of requirements. Although the casting may show a large degree of change from pattern size, yet in most cases the individual variation between several castings from the same pattern is comparatively small.

The dimensional data on castings have been selected to illustrate the variables encountered in works practice, and should not be regarded necessarily as examples of the "best possible" accuracy obtainable on all castings. The metallurgical data were obtained as accurately as possible, and are, generally speaking, "accurate and typical" under the particular conditions existing.

The investigations of the Committee were divided into various groups, viz., malleable cast iron, steel, grey cast iron and non-ferrous metals, and the data obtained are set out below.

Malleable Cast Iron

(From data submitted by the Malleable Sub-Committee.)

The following notes apply generally to both whiteheart and blackheart malleable cast iron, but the data are taken from tests on blackheart.

(1) Contraction of the hard iron is constant within wide ranges of chemical composition, casting temperatures and melting conditions. (See data given later.)

(2) Contraction of the annealed iron (*i.e.*, final contraction) is very varied and depends on many factors. (See separate data.)

(3) A standard contraction is used by patternmakers and may be $\frac{1}{8}$ in. or $\frac{3}{16}$ in. per ft.

(4) Castings show contraction which digresses from the contraction rule, due to particular shape and section.

(5) This digression from contraction rule can be covered by the patternmaker either from experience or by "trial and error."

(6) Thus it is advisable for a founder to produce his own pattern.

(7) A pattern supplied by a customer may not be suitable to produce an accurate casting because of lack of knowledge indicated under 3 and 5.

(8) It is thus possible for a founder to supply a casting from a customer's pattern which may not agree with the customer's requirements, but may be "true to pattern."

(9) Assuming the accuracy of a pattern according to 3 and 5, errors in dimensions can now arise because of moulding difficulties.

(10) Methods of moulding vary in intrinsic accuracy obtainable. This has already been dealt with.

(11) As mentioned under 2, the annealed contraction can vary considerably. The main factors affecting it are:—(*a*) Original total carbon content, and (*b*) extent of decarburisation, which is determined by: (1) packing material; (2) temperature and time of anneal; (3) composition of iron; (4) effectiveness of pot-luting, and (5) composition of oven gases. (See separate data given later.)

(12) It appears from the data just mentioned that the average contraction on blackheart after annealing (per Keep's bar) is 0.130 in. per ft. (approximately $\frac{1}{8}$ in.) and that variations compatible with good practice are from 0.112 in. to 0.151 in. (approximately $\frac{7}{64}$ in. to $\frac{5}{32}$ in.).

(13) Assuming castings in the hard state to be exactly correct to pattern (*i.e.*, to have suffered the normal contraction only) then the errors introduced by annealing may be (per notes 3 and 12):—

Using $\frac{1}{8}$ in. contraction rule: from plus $\frac{1}{64}$ in. to minus $\frac{1}{32}$ in.

Using $\frac{7}{64}$ in. contraction rule: from plus $\frac{5}{64}$ in. to plus $\frac{1}{32}$ in.

Data on Contraction of Blackheart Malleable

(*See notes*, 1, 2, 11 *and* 12.)

The following summary gives briefly the results obtained on tests carried out over a period of 12 years, using Keep's 12 in. bar cast in chills. During the period as many variables as possible have been examined. It may be taken for granted, however, that all test bars were free from primary graphite and that they were completely graphitised on annealing.

Hard Iron Contraction.—With total carbon 2.10 to 2.75 per cent.—average = 0.230 in. per ft. (±0.007). The highest contraction is usually associated with the lowest carbon and *vice versa*, but the variation is so slight that it may be assumed that the contraction is constant for all conditions which conform to normal practice.

Annealed Iron Contraction (hard contraction and soft expansion).—Average = 0.130 in. per ft. (plus 0.047 in., minus 0.030 in.). The highest contraction is associated with the lowest total carbon and *vice versa*, *e.g.*, original total carbon 2.10 to 2.24 per cent. = average contraction 0.141 in. per ft.; original total carbon 2.54 to 2.84 per cent. = 0.127 in. per ft.

Among the other factors noted under 12, time and temperature of anneal have a profound influence, *e.g.*,—

High temperature and long time—average contraction 0.134 in. per ft.

Low temperature and short time—average contraction 0.127 in. per ft.

From a careful examination of all data it would appear that within the limits of chemical composition, temperature, time and other annealing conditions compatible with good practice, the annealed iron contraction can vary:—

From 0.112 in. per ft. (approximately $\frac{7}{64}$ in. per ft.)

to 0.151 in. per ft. (approximately $\frac{5}{32}$ in. per ft.),

giving a total variation of a little over $\frac{1}{32}$ in. per ft.

Effect of Re-heating Blackheart.—(As for "setting.") Keep's 12-in. test bars cast in chills were used. After annealing the bars were heated to 700 deg. C. for 5 min. and cooled in air.

Average of five bars.—Annealed contraction = 0.106 in. per ft.

Average of five bars.—Re-heated contraction = 0.093 in. per ft.

Note.—The actual figures are lower than recorded in the previous data, and are probably due to these bars having higher total carbon contents (2.6 to 2.74 per cent.).

Whiteheart Malleable.—(Taken on Keep's 12-in. test bars cast in chills.)

Average hard contraction—0.255 in. per ft.

Average annealed contraction—0.278 in. per ft.

Note.—In the case of whiteheart appreciable differences in data obtained in different plants may be encountered, due to the wide range of chemical composition, annealing conditions, and types of structure produced for various classes of work.

Data on Blackheart Castings from Regular Production

(*Note.*—These data cover all variables—mechanical and metallurgical.)

Since the primary object of this investigation was the determination of practical casting limits on dimensions of castings produced under normal works conditions, it was decided to collect the data from patterns already in production rather than from patterns made later with this investigation in mind.

A number of patterns were selected from several different foundries, all of which were producing castings acceptable to the customers concerned, and measurements were carried out on six castings taken at random from each pattern.

Table I given above shows particulars of measurements taken on a number of hard castings, mainly with the object of determining:—(*a*) The variation exhibited between different castings from the same pattern (this, generally speaking, is found to be reasonably small), and (*b*) the maximum contraction from the pattern size. This will be seen to vary over a wide range, not only as between different patterns, but also between different dimensions on the same casting.

On examining Table I, it will be noticed that in the great majority of cases the amount of variation between castings from the same pattern is reasonably small. In other words, it can be stated that under a given set of manufacturing conditions, reasonable uniformity of dimensions can be attained.

The amount of contraction from the pattern size exhibited in castings of different design is, however, seen to vary to a considerable extent. Extremes of change from pattern size, expressed in inches per foot, vary from an expansion of $\frac{3}{16}$ in. per ft. (example C, $1\frac{13}{64}$ in. dimension) to a contraction of $\frac{1}{32}$ in. per ft. (example D, $2\frac{9}{32}$ in. dimension). These are both taken on small dimensions, and are therefore somewhat exaggerated when expressed in terms of inches per foot.

Table I.—*Dimensional Variations on Hard Castings.*

Method of moulding.	Description of casting.	Dimension taken.	Pattern size, in in.	Casting dimensions, in in. Max.	Min.	Variation.	Max. contraction from pattern, in in.
(*a*) Stripper ..	Auto. differential carrier	Flange on joint	$11\frac{11}{64}$*	$10\frac{31}{32}$	$10\frac{15}{16}$	$\frac{1}{32}$ } $\frac{1}{16}$†	$\frac{1}{64}$
		At right angles to joint ..	$11\frac{11}{64}$*	11	$10\frac{31}{32}$	$\frac{1}{32}$ }	$\frac{1}{64}$
		Between horns	$4\frac{23}{64}$*	$4\frac{1}{16}$	$4\frac{1}{16}$	$\frac{1}{16}$	$\frac{7}{64}$
		Length	$14\frac{1}{2}$	$14\frac{1}{16}$	$14\frac{1}{16}$	$\frac{1}{16}$	$\frac{7}{64}$
(*b*) Air machine	Auto. starter bracket	Length	$6\frac{7}{16}$	$6\frac{11}{16}$	$6\frac{11}{16}$	Nil.	$\frac{1}{32}$
		Length to cored face ..	$5\frac{21}{64}$*	$5\frac{1}{8}$	$5\frac{9}{16}$	$\frac{1}{16}$	$\frac{5}{64}$
		Flange on joint	$4\frac{21}{64}$*	$4\frac{13}{16}$	$4\frac{17}{32}$	$\frac{1}{16}$	$\frac{5}{64}$
		At right angles to joint ..	$4\frac{21}{64}$*	$4\frac{9}{16}$	$4\frac{17}{32}$	$\frac{1}{16}$	$\frac{1}{64}$
(*c*) Jolt squeeze	Auto. differential case	Length	$4\frac{21}{64}$*	$4\frac{13}{32}$	$4\frac{7}{16}$	$\frac{1}{32}$	$\frac{5}{64}$
		Diameter of flange ..	$10\frac{9}{64}$	$9\frac{11}{32}$	$9\frac{21}{64}$	$\frac{1}{64}$	$\frac{7}{64}$
		Depth	$1\frac{13}{64}$*	$1\frac{17}{64}$	$1\frac{13}{32}$	$\frac{1}{64}$	$+\frac{1}{32}$
		Diameter of body ..	$7\frac{17}{64}$*	$7\frac{1}{16}$	$7\frac{9}{64}$	$\frac{1}{64}$	$\frac{1}{64}$
(*d*) Jolt squeeze	Auto. front hub	Diameter of flange ..	$9\frac{7}{8}$*	$9\frac{3}{4}$	$9\frac{13}{64}$	$\frac{1}{64}$	$\frac{11}{64}$
		Distance between flanges	$2\frac{9}{32}$*	$2\frac{7}{32}$	$2\frac{9}{32}$	$\frac{1}{32}$	$\frac{1}{32}$
		Diameter of small flange	$7\frac{1}{8}$	$7\frac{1}{32}$	$6\frac{31}{32}$	$\frac{1}{32}$	$\frac{1}{32}$
		Length	$5\frac{33}{64}$	$5\frac{1}{2}$	$5\frac{15}{32}$	$\frac{1}{32}$	$\frac{1}{64}$
(*e*) Jolt ..	Auto. front hub	Diameter of flange on joint	$12\frac{31}{32}$*	$12\frac{3}{4}$	$12\frac{15}{16}$	$\frac{1}{32}$	$\frac{1}{64}$
		At right angles to joint ..	$12\frac{31}{32}$*	$12\frac{15}{16}$	$12\frac{29}{32}$	$\frac{1}{64}$	$\frac{17}{64}$
		Boss to flange	2*	2	$1\frac{31}{32}$	$\frac{1}{32}$	$\frac{1}{32}$
		Length	$5\frac{33}{64}$	$5\frac{31}{32}$	$5\frac{15}{16}$	$\frac{1}{32}$	$\frac{5}{64}$
(*f*) Floor ..	Flywheel ..	Diameter of plate ..	$16\frac{13}{32}$	$16\frac{3}{64}$	$16\frac{1}{32}$	$\frac{1}{64}$	$\frac{3}{64}$
		Depth of boss	$3\frac{1}{16}$	$3\frac{1}{8}$	$3\frac{7}{64}$	$\frac{1}{64}$	$+\frac{1}{64}$
		Thick plate	$\frac{3}{8}$	$\frac{13}{32}$	$\frac{25}{64}$	$\frac{1}{32}$	$+\frac{1}{32}$
(*g*) Floor ..	Trough‡ ..	Length	$49\frac{1}{32}$	—	$47\frac{13}{32}$	—	$1\frac{1}{8}$

* Cored dimension. † Total variation. ‡ Measurements of one casting only.

Table II.—*Dimensional Variations Due to Annealing.*

Description of casting.	Method of moulding.	Dimension taken.	A.	B.	C.	D.	E.
(1) Auto. differential carrier	Stripper ..	Flange on joint	$11\frac{11}{64}$*	$\frac{1}{32}$	$\frac{1}{64}$	$\frac{1}{16}$	$\frac{1}{8}$
		Flange at right angles to joint ..	$11\frac{11}{64}$*	$\frac{1}{32}$	$\frac{1}{64}$	$\frac{5}{64}$	$\frac{7}{64}$
		Length	$14\frac{1}{2}$	$\frac{1}{32}$	$\frac{1}{16}$	$\frac{5}{64}$	$\frac{1}{8}$
(2) Auto. starter bracket	Air machine	Length	$6\frac{7}{16}$	Nil.	$\frac{3}{32}$	$\frac{5}{64}$	$\frac{5}{64}$
		Flange on joint	$4\frac{21}{64}$*	$\frac{1}{16}$	$\frac{7}{64}$	$\frac{1}{16}$	$\frac{5}{16}$
(3) Auto. front hub	Jolt ..	Flange on joint	$12\frac{31}{32}$*	$\frac{1}{32}$	$\frac{1}{16}$	$\frac{7}{64}$	$\frac{1}{8}$
		Flange on joint at right angles	$12\frac{31}{32}$*	$\frac{1}{64}$	$\frac{1}{64}$	$\frac{3}{64}$	$\frac{3}{64}$
		Length	$5\frac{33}{64}$	$\frac{1}{16}$	$\frac{1}{64}$	$\frac{1}{64}$	$\frac{1}{64}$
(4) Rear brake drum		Internal diameter	$14\frac{1}{2}$	$\frac{1}{16}$	$\frac{3}{32}$	$\frac{1}{16}$	$\frac{1}{8}$
		Top face diameter	$9\frac{1}{16}$	Nil.	$\frac{1}{8}$	Nil.	$\frac{1}{16}$
		Depth	$8\frac{1}{16}$	$\frac{1}{32}$	$\frac{1}{32}$	$\frac{1}{64}$	$\frac{1}{64}$
(5) Channel section		Length	$19\frac{1}{4}$	—	—	$\frac{1}{8}$	$\frac{9}{32}$

* Core dimensions.

Although the figures in Table I are self-explanatory, a few examples may be extracted and compared in terms of inches per foot contraction from pattern size.

Examples A and B.—All dimensions show a fairly uniform contraction of approximately $\frac{1}{4}$ in. to the foot.

(*Continued on page* 105.)

Factories and Workshops

CHIEF INSPECTOR'S ANNUAL REPORT, 1935

The Annual Report* of the Chief Inspector of Factories and Workshops for 1935, recently issued, deals with the usual wide range of subjects, including safety, health, hours of employment, and welfare.

Lighting

Discussing lighting conditions, the Report states that improvement in the artificial lighting of factories, though slow, continues. This improvement is specially noticeable in rural districts through the introduction of the grid system. The principal defect is excessive glare, and it is still very usual to find installations consisting of completely unshaded gas-filled lamps, situated little above eye-level.

Electrical discharge lamps, sometimes accompanied by gas-filled lamps for colour correction, are now frequently met with, though their use does not seem to be increasing rapidly. They are usually found in large open shops with plenty of head room such as foundries. The use of daylight lamps seems to be generally confined to rooms in which discrimination of colour differences is important.

In an iron foundry a system recommended by the Electric Light Manufacturers' Association has been adopted. The lighting is done by means of R.L.M. type 300-watt lamps which give a glareless light. The lamps are so distributed that there are no dark spots and give an illumination of 13 foot-candles over the foundry floor. The manager claims the following advantages:—(1) In the winter months the output fell about 10 per cent. with the old system of lighting. Now he finds no fall. (2) The pouring holes are clearly visible in the black sand moulds. (3) There is a drop in the number of petty accidents. (4) Molten metal can be carried more safely. The electric light bill has only increased £2 over the year which the manager points out might be accounted for by a few darker days, so that he is enthusiastic over the new conditions.

A system of indirect lighting has recently been installed at a sheet rolling and galvanising works, to facilitate the visual inspection of galvanised sheets. Over each inspection table, on to which the sheets are delivered from the galvanising machines, an inverted "V"-shaped hood about 8 ft. long is hung some 6 ft. above the table. The inside of this hood is painted a "dead" white and a row of electric lamps contained in a central trough running the length of the hood and level with its bottom edges cause a soft even light to be reflected on the sheets without glare.

Accidents

There was again a considerable increase in the total number of accidents reported, the number being 149,696 including 843 fatalities in 1935, as compared with 136,858 including 785 fatalities in 1934. Compared with 1933 the total accidents increased by 32 per cent. and the fatal accidents by 22 per cent. Data from which the successive frequency rates of accidents at all premises under the Factory and Workshop Acts could be exactly calculated are not available, but there is no reason to believe that the increased total represents any increase in the accident rate based on man-hours worked. As mentioned in previous reports, a further factor in an increase of accidents associated with increased employment is the temporary greater accident proneness of workers engaged in operations which are new to them, or for which they have become out of practice while unemployed. A specific instance of this is that of a large textile factory which took on several hundreds of new workers. The accident rate immediately rose, but after some weeks, although the number employed was the same, the rate fell.

A minor, but not negligible, factor tending to increase the number of reported accidents, which operates every year, is a better standard of reporting, as the result of instructions given by the Inspectors and legal proceedings in cases of serious default.

There is no doubt that, as the result of the matter having been kept continuously to the fore for a number of years past, the dangerous practice of approach to unfenced overhead shafting in motion for shipping belts, oiling, etc., has become decidedly less prevalent. The practice, however, dies very hard, and fatal and other accidents due to such approach are again reported from all Divisions, in spite of the publicity given to the matter by legal proceedings in all appropriate cases.

On the investigation of such accidents in large works it is sometimes found that dangerous practices in the shipping of belts, etc., have existed, without the knowledge and contrary to the wishes of the management, owing to the matter not having been gone into in sufficient detail. The mere issue of instructions that shafting in motion must not be approached is not sufficient; a detailed examination of the transmission machinery in the various departments should be made by someone in authority, to see whether the conditions are such that compliance with the instructions by the men concerned is reasonably practicable, or whether other precautions, such as further sectionalising of the machinery, are needed for safety.

Thirty-seven accidents occurred to persons who were on or near overhead gantries owing to the movement of overhead cranes. Accidents in this class should be guarded against by a proper system for preventing all approach to crane tracks for maintenance or repair work before the drivers have been warned, and the cranes made "dead" by opening the main switches or removing fuses. Several accidents due to overwinding occurred at overhead cranes, where limit switches were wanting or were not properly maintained.

Pneumatic Tools and Health

Some further inquiry on the effects of health of the use of pneumatic tools was made among a small group of young stonemasons who had been using one-hand pneumatic hammers more or less regularly for periods of about three years. Detailed clinical examinations of six men revealed no evidence of ill-effects beyond a tendency to "dead fingers" in the hand exposed to the "exhaust" from the pneumatic tool; the hand operating the tool was in no case affected. The men examined were agreed that this tendency for the fingers of one hand only to go "dead" on exposure to cold persisted after they had ceased work with pneumatic tools. The interesting question is involved as to whether the hyperactivity so induced in the local cold-resisting mechanism may, if sufficiently intense or prolonged, result in such vascular changes as would interfere seriously with the nutrition of the affected part. No bone or joint changes such as might be attributed to sustained vibration were observed in these subjects, but it is unlikely that such lesions would result from the use of small, light tools.

Dust Diseases

There has been no reduction in 1935 in the number of deaths from silicosis and asbestosis, nor was this to be anticipated having in mind the character, and in particular the usually slow development of the disease. Fifty deaths (57 in 1934) from silicosis, and 76 (50 in 1934) from silicosis with tuberculosis, have come to the notice of the Department during the year, together with 11 deaths (6 in 1934) from asbestosis, and 4 (8 in 1934) from asbestosis with tuberculosis. The pottery industry accounts for many cases of silicosis, and the particularly disquieting feature is cases with comparatively short exposure amongst female dust-tile pressers.

Sandblasting.—Special inquiries have been made as to the extent to which steel shot or grit may be substituted for siliceous substances as an abrasive in sandblasting. The number of firms who are adopting steel shot for the cleaning of iron, steel and brass castings, forgings and sheets and for the preparation of surfaces prior to enamelling, metallising, etc., is rapidly increasing, and in a short time it is anticipated only a small minority of firms will still be using sand or flint grit. A complete range of graded shot is now available, and provided a suitable and efficient blasting plant is used there are very few processes at present carried on which could not be done equally well following on shot blasting. One very real difficulty arises where the adherence of particles of steel shot to the article causes an undesirable chemical action during subsequent processes, *e.g.*, a piece of glass which has been frosted with shot when returned to the melting pot may cause a green coloration in the mixing. Where such difficulties are encountered there is, however, in almost every case an alternative which can be adopted, either by treatment of a chemical nature or by the use of another abrasive.

Vitreous Enamelling.—In vitreous-enamelling works the provision of exhaust ventilation and other dust-suppressing arrangements in the departments where the enamels are made, to guard in particular against the risk from dust of siliceous materials, continues to extend. Further advance can be recorded. Apart from the more direct safeguards, experience shows clearly that the difficulties to be overcome can be more readily dealt with, if suitable premises are provided. This has been strikingly shown at one works where a three-storey building has been recently built and equipped to take the place of the two-storey building formerly used. The materials on reception are hoisted to the top floor, thence emptied into storage hoppers on the intermediate floor, these hoppers extending downwards to about head level. The mechanical mixers are on this floor. The mixings in turn are passed downwards into the melters on the ground floor. All processes have been very well enclosed and localised exhaust particularly well applied. In a suitably-equipped three-storey building exposure to dust from the emptying, lifting, weighing and other handling of dangerous materials can be very greatly reduced.

Grinding of Metals.—The grinding of metals on sandstone wheels has been recognised for generations as a cause of silicosis and an increased mortality from tuberculosis. During the five years, 1930 to 1934, the total number of deaths certified in England and Wales as due to silicosis, with or without tuberculosis, was 142. The numbers for the consecutive years show a decline: 36, 36, 31, 20 and 19.

* Cmd. 5230. H.M. Stationery Office, Adastral House, Kingsway, London, W.C.2. (Price 2s. net.)

The Steel Inquiry

In reply to a question in the House of Commons last week, Mr. Runciman stated that the Import Duties Advisory Committee to inquire into the steel industry would consist of the following gentlemen:—The Right Hon. Lord May, K.B.E., Sir Sydney J. Chapman, K.C.B., C.B.E., and Sir Allan Powell, C.B.E. The terms of reference are:—

"To examine the present position of the iron and steel industry in the light of all the data now available and in so far as is practicable to report, with due regard to the national interest, on the general lines of its future development."

Later the Committee gave notice of their appointment.

Any representations in regard to this matter should be submitted, as fully as possible in writing in the first instance, to the Secretary, Import Duties Advisory Committee, Caxton House (West Block), Tothill Street, Westminster, London, S.W.1.

British Foundry School

AN ENCOURAGING YEAR

The first annual general meeting of the British Foundry School was held at Birmingham on July 21, Mr. R. G. Hosking (Rugby) presiding. An abstract of the first Annual Report is appended.

FIRST ANNUAL REPORT

(Abstract)

The present report constitutes the first annual report and statement of accounts of the Governing Body of the British Foundry School. The first financial year was arranged to end on March 31, 1936, and the statement of accounts includes all receipts and expenditures to this date. As far as the progress of the School is concerned, however, the report extends virtually to the end of the first session, July 31, 1936.

The School originated in proposals put forward to and considered by the Board of Education in 1933, when Sir Harold Hartley, C.B.E., M.C., F.R.S., was President of the British Cast Iron Research Association. The Board's interest justified a serious attempt to ascertain whether its establishment would receive sufficient support. To this end a group of technical institutions, trade associations and research associations concerned with the founding industry were invited to consider the desirability and practicability of the scheme. The response justified the formation of a Provisional Committee to stimulate industrial interest.

The founding industry is concerned with the manufacture and application of cast metals in any form, and includes casting of steel, grey iron, white and chilled iron, malleable cast iron and the non-ferrous metals. The processes concerned are characterised by a marked similarity, irrespective of the materials employed, and the technique is strikingly different from that employed in any other section of the metallurgical and engineering industries. There is thus a common basis for instruction in both the science underlying practice and the art itself. The practice of the art has extended over many generations and was originally empirical. In recent years great advances have been made in the application of the science of metallurgy to founding. The industry has become conscious of the need for the application of science and the establishment of the British Non-Ferrous Metals Research Association, The British Cast Iron Research Association, and the Iron and Steel Industrial Research Council of the British Iron and Steel Federation reflect this. Remarkable developments are also taking place in the foundry in the application of methods of continuous production, which have been found to involve a much higher degree of technical control. Other industrial countries, notably France and Germany, have established schools in which the key men of the industry, metallurgists, engineers, managers, may be trained. The British Foundry School was envisaged as an organised way of providing these men, suited to the particular conditions of this country and British foundries overseas.

The normal method of recruitment of leaders in the industry has, in the main, been by promotion of the more able and ambitious men, who have acquired lengthy practical experience through apprenticeship in the foundry or pattern-shop. In recent years a few university graduates and others with adequate technical training have also entered the industry, but their number is still comparatively small. Bearing in mind the limited output of metallurgical graduates from British universities and the wide range of metallurgical industries which they serve, it does not appear that a very large increase may be expected from these sources. In view of the rapid expansion of foundry science, it was considered that the school could most satisfactorily serve the industry by providing for men who have already entered it, who have acquired adequate practical training and preliminary education and who have shown by their energy and ability that they are marked out for further progress. In this way the school makes provision for a comparatively mature student who knows what he wants to learn and who is keen to do so. The problem of placing men of technical training without practical experience does not, in these circumstances, arise. It was believed that the school should be national in character, should offer a State-recognised diploma, and that it should be governed by representatives of the industry, independent of, but in full co-operation with, other educational bodies. A full-time course of one year's duration was considered to be adequate having regard to the matter to be taught and the time for which men engaged in the industry could conveniently be spared.

It was recognised that the number of students would inevitably be comparatively small, and until the industry makes a much wider demand for scientifically trained men, it was decided to limit the number of places to thirty in any one year. It was evident that a school of such a size could not hope to be housed in a separate building and, indeed, that certain advantages would accrue if it were associated with a recognised technical institution. On geographical, educational and industrial grounds, it was decided that the school would most conveniently be located in Birmingham. The Birmingham Education Committee was therefore approached to see whether the school could be housed in the buildings of the Central Technical College. The negotiations were satisfactorily completed, and the governing body desire to express their warmest thanks to the Committee and its Chief Education Officer, Dr. P. D. Innes, C.B.E., for their whole-hearted co-operation throughout.

The institutions undertaking to support the scheme financially were invited to send representatives to a Provisional Committee, the first meeting of which was held on May 9, 1935. The complete list of these institutions is as follows: British Cast Iron Research Association; British Non-Ferrous Metals Research Association; City and Guilds of London Institute; Institute of British Foundrymen; Institution of Automobile Engineers; Institution of Mechanical Engineers; Iron and Steel Industrial Research Council of the British Iron and Steel Federation; Iron and Steel Institute; The National Light Castings Ironfounders' Federation; and Welsh Engineers and Founders' Association. The school also has the support of the Institute of Metals.

At the second meeting of the Provisional Committee, it resolved itself into the Provisional Governing Body. The provisional constitution adopted provided for representatives of subscribing institutions as above indicated; of subscribing firms and of public bodies, not exceeding nine representatives in number; of the Board of Education and Birmingham Education Committee; and of co-opted members, not exceeding three in number. Mr. R. G. Hosking was elected chairman, and Alderman W. Byng Kenrick vice-chairman. Mr. J. G. Pearce was elected honorary adviser and honorary treasurer, and Mr. G. H. Rogers secretary. In due course it is proposed to incorporate the school as a company, limited by guarantee and not operating for profit. During the year the governing body held seven meetings, with an average attendance of fifteen and six committee meetings were held, with an average attendance of seven.

Finance

A fee of £30 per annum was fixed for students taking the diploma, although the governing body, at its discretion, admits non-diploma students at a fee of £100 per annum. It was estimated that, exclusive of students' fees, the cost of operation would be approximately £2,000 per annum. The Board of Education generously undertook to provide a grant to meet any deficit on working, up to £1,500 per annum, provided £500 per annum was obtained from industrial sources. The institutions listed above provided, for the first year's working, contributions totalling £245 10s. (£25 in respect of the session 1936-37), and contributions from firms and individuals were received, making a total from industrial sources of £275 12s., giving a total of £521 2s.

The governing body desires to thank contributors for their interest and support, and to express the hope that the progress outlined in this report will justify the continuance and, indeed, extension of industrial support in future. These contributions by no means represent the full cost to industry. With one exception, all the students enrolled for the first session were nominated by their employers, and have been maintained by them. It is estimated that the approximate minimum maintenance cost of a student for the year is £110-£120.

Students

Thirteen students enrolled for the first session, having an average age of about 25. The governing body desires to make it clear that, while the students have, in the main, been nominated by works in which they are already employed, applications are welcomed from students who may wish to take the course independently. Various officers of Education Committees throughout the country have indicated that requests for assistance from students in their areas qualified to take the course, but unable to do so for financial reasons, would be sympathetically considered.

The students have formed an association of ex-students of the school for maintaining social and professional contacts, provisionally called the Foundry Technical Group.

Session

The session opened on October 15, 1935, when the chairman of the governing body addressed the students. In future years the session will begin in September. The session 1936-37 will open on September 21.

Permanent Staff

After careful consideration, the governing body appointed Mr. J. Bamford as Lecturer-in-Charge. He passed through a five-year foundry apprenticeship with the British Thomson-Houston Company, Limited, Rugby, and subsequently took the company's apprenticeship course for engineers, being then appointed technical assistant to the foundry superintendent. He holds the B.Sc. degree in engineering of the University of London, and has taken three national certificates in engineering. He began his duties on October 1, 1935. Mr. C. A. Timms was appointed demonstrator.

The lecture and laboratory work in chemistry during the first session was taken by Mr. M. D. Bassett, B.Sc., and in physics by Mr. A. J. E. Swann, M.Sc., of the staff of the Central Technical College.

Curriculum

The course is an arduous one, and requires the students' full attention. It covers a period of about forty weeks of over thirty-nine hours per week. Students are also required to do a considerable amount of work in their own time. An outline of the curriculum is given in an appendix. Lecture and laboratory work is provided for in metallurgy, founding, physics, chemistry and engineering. Since students have had practical training prior to entering the course, little addition is required to the accommodation and equipment of the Department of Metallurgy of the College to suit the full requirements of the school. A special feature of the course, which is carried on throughout the

session, is the conduct by the students of a series of practical studies. These fall into two categories, moulding and casting studies, and foundry projects. In the former the student is given a casting or blue print with the necessary information about the number required, and is expected to prepare a complete scheme of foundry production, including data on the composition, melting charges and losses of the raw material, the weight of the casting, machining allowances, the construction of the pattern and core boxes, the method of moulding and details of sand to be employed, and its treatment, runners, risers, etc., the method of pouring, together with the man-hours required for manufacture, and cost. In the latter the student is expected to design a foundry or to re-model an existing foundry to specified requirements. These studies are carried on throughout the year, and two-thirds of the time devoted to the diploma examination is expended in dealing with two tasks of this character.

A feature of the course to which special attention is drawn is the delivery of lectures by specialists. One hundred and twenty of these lectures were given during the session by 76 gentlemen. It is desired to thank Associate Lecturers for their co-operation in providing for this group of lectures, which were all followed by discussions in which the students took part. The students have also been addressed, as opportunity offered, by distinguished visitors from overseas. The governing body is greatly indebted to some Associate Lecturers, who have allowed their fees, and in some cases also travelling expenses, to be returned to the school funds.

Visits to Foundries

A large number of visits have been paid during the year to foundries, culminating in a visit to Scotland, during which ten plants were visited in four days. The governing body is deeply sensible of the debt the school owes to foundries who have so kindly permitted the students to make these visits and in a number of cases for the hospitality they have provided.

Students have had opportunities during the year of preparing short Papers on foundry subjects, of taking part in debates on matters of foundry controversy and preparing reports on specified subjects calling for the collection and critical analysis of existing data.

Diploma Examinations

The Governing Body decided that the Diploma Examination should consist of four subjects, as follows: Foundry Metallurgy (two Papers); Foundry Technology; Foundry Management, and Moulding and Casting Studies and Foundry Projects. The written Papers (metallurgy, technology, management) are of three hours' duration each. For the ferrous study and/or project (cast iron or cast steel) twelve hours are allowed, and for the non-ferrous study and/or project, nine hours. The Papers set at the Diploma examination will be available to those interested.

The following authorities have acted as assessors in the preparation and marking of the Papers:—

Foundry Metallurgy: Principal C. A. Edwards, D.Sc., F.R.S. (Principal and Professor of Metallurgy, University College, Swansea).

Foundry Management and Foundry Technology: Mr. E. R. Briggs, M.Inst.C.E., M.I.Mech.E. (Rugby).

Cast Iron Moulding and Casting Study and Project: Mr. F. J. Cook, M.I.Mech.E. (Birmingham).

Steel Moulding and Casting Study and Project: Dr. C. J. Dadswell (Sheffield).

Non-Ferrous Moulding and Casting Study and Project: Mr. J. A. Clavey (Manchester).

Foreign Foundry Schools

During the year the Honorary Adviser and the Lecturer-in-Charge visited the Foundry Institute of the Technical High School at Aachen, and the Foundry High School in Paris. The School of Metallurgy at Aachen is the largest in Germany, and part of it, under Professors Piwowarsky and Nipper, is devoted to the specialised training of students for the founding industry in a full university course of four years' duration. The existence of the Aachen School is of incalculable benefit to the German founding industry.

The Ecole Supérieure de Fonderie at Paris offers a specialised course of training of about seven months duration to students from the industry. While the British school has been evolved to suit the requirements of Great Britain, it has many parallels with the French school, and the French industry is to be congratulated on the successful operation of the school over a period of about twelve years, largely due to the ability and devotion of its Director, Monsieur E. Ronceray.

Acknowledgments

The Governing Body desire to express their appreciation of the valuable assistance which the School has received from Dr. D. S. Anderson, Principal, and Dr. F. Johnson, Head of the Department of Metallurgy, of the Central Technical College. Mr. John Belliss has also assisted the School in a number of ways, and Mr. J. G. Pearce has presented about fifty volumes to form the nucleus of a library. Mr. J. B. Williams has offered to present supplies of moulding sand, and Geo. Salter & Company, Limited, have kindly loaned a B.C.I.R.A. Sand Compression Tester.

Conclusion

The Governing Body has been impressed with the calibre and enthusiasm of the students, and believes that this augurs well for the future, both of the School and of the industry. It believes that the results of the first year's working have amply justified this novel experiment, and would welcome suggestions or offers of assistance from all those interested.

Making Good Past Neglect

The CHAIRMAN, in proposing the adoption of the report, said the purpose of the meeting was to afford an opportunity of rendering an account of what had been done during the past year, to talk about the present and to ventilate ideas for the future. The industry with which they were connected—the founding of metals—was probably one of the oldest, yet in some respects it was undoubtedly one of the most backward. An American had said that the British won only one battle—the last—and there was a great deal of truth in the statement. In the matter of intelligent regard of the industry with which they were associated, we had had to wait until France and Germany had shown us the way before we began to do anything at all. The technical side of the founding art had been shockingly neglected. "But we are here to-day," Mr. Hosking added, "to indicate that that neglect is being made good, and taking the analogy of the battle, I am certain that it is the determination of the students in this room that we are going to win that last battle. Although we are starting subsequent to France and Germany, we are not going to be beaten; in fact, we are going to show them that we are still capable of winning battles."

Co-operative Origin

The existence of the School, the Chairman continued, had been made possible, and could only have been made possible, by the co-operation of a number of important bodies in the country, whose support they greatly valued. They had experienced many difficulties—to find a home for one thing—and in that respect they desired to express appreciation of the fine attitude of the Birmingham Corporation through the Education Committee, of which Alderman Byng Kenrick was chairman. It was due to the influence of Alderman Kenrick and the acquiescence of the authorities, that the School had found a home in the Birmingham Technical College. That was the sort of action they would expect from Birmingham, the pioneer of high municipal endeavour. They had also received a number of subscriptions from the industry and the wholehearted support of the Board of Education. The backing of the industry was not nearly as good as it ought to have been. He thought they would have failed in one of their efforts unless the list was very materially extended in the future. When it was realised that the turnover of the founding industry was something like £40,000,000 a year, it did not seem very satisfactory that the industry found itself able to subscribe only about £300 a year towards the expenses of the School. He was convinced that when the industry realised its responsibilities in this matter it would vastly improve upon what had been done so far. It was true to say, however, that the amount subscribed during the past year, together with the financial support of the associated bodies and the large sum received from the Board of Education, had been sufficient to see them through. In fact, they had a very small balance on the right side. But he would like, as an industrialist, to feel that the industry was willing to face up to this matter, so that it would not be necessary to call upon the Board of Education to carry such a large proportion of the financial burden.

Visiting Lecturers

During the past year the work carried on had benefited very greatly by lectures given by a number of visiting lecturers, all of whom were experts in some particular branch of the work. He felt that these outside lecturers visiting the School, together with the visits which the students themselves paid to works up and down the country, constituted two of the most valuable pieces of experience which the students could have. They started the year with thirteen students, all full of enthusiasm, and he believed they were just as enthusiastic to-day. The students had all sat for the Diploma examination, the results of which he understood were not yet available. He hoped they would realise that they were going out into the world to preach a new gospel. The success or otherwise of the School would not a little depend upon the work done by students after leaving the School, and the influence they exerted upon those with whom they came in contact.

Local Help

ALDERMAN W. BYNG KENRICK, in seconding the motion, said that while it was quite right to appeal to those engaged in the industry to increase their support, he thought a warm tribute of thanks should be offered to those firms who had sent the first students, and were paying their fees and maintenance. There was no doubt that the gain from the studies would inure largely to the particular establishments sending the students, but after all the firms were doing a national service by supporting the School as they had done. He hoped it would be possible to convince industrialists that it would be well worth their while to send students and to meet the charges for their education. As to the assistance rendered by Birmingham, the Midlands was one of the chief centres in this country of the founding trade, and having the accommodation and a staff which could give some help to the specialised staff of the School, they would have been both churlish and short-sighted if they had not welcomed the establishment of the School in Birmingham.

Influence of Cast Structure on Wrought Metals

MR. J. G. PEARCE, Honorary Adviser and Honorary Treasurer, who supported the motion, said the School was concerned with all aspects of the founding industry. Regardless of the material to be cast, there was an essential unity of the principles underlying foundry practice, and on that unity they based the instruction on which the School stood. It would be unfair, he thought, at this early stage to infer that the

industry had been unresponsive to the scheme because it contributed, directly, such a comparatively small sum. He had no doubt that as the School became more widely known the industrial support would increase.

The importance of the founding industry, particularly the technical side of it, transcended that of the mere economic importance of the industry in so far as it was concerned with the manufacture and sale of castings. With insignificant exceptions, every metal passed through the cast state on its journey towards the finished product, whether that was a casting in itself, or was subsequently refined or treated to put it into a wrought form; and the properties that were assumed in the cast state were not subsequently entirely lost. The fundamental work that was done metallurgically and technically for the industry was an application, therefore, which went far beyond the industry itself.

Application to Industry

He was very much impressed with the extent to which the scheme had had the co-operation of such a large number of bodies and individuals. It had been an exhilarating year. There was a body of keen and able students who, they felt, would go far in their chosen work. They hoped the scheme was the beginning of bigger things in the future. It was doing something towards the winning of the last battle to which the chairman had referred that they had provision in this country which at least began to approach that made now for a number of years in France, Germany, and America. They were particularly anxious that trained men should apply in their respective works the developments that were proceeding in the industry. It was recognised in industrial countries all over the world that the last fifteen years had been a ferment of development with regard to the foundry.

The report was adopted.

Members of the Governing Body were thanked for their services and reappointed for the ensuing year, subject to any changes in representation which the subscribing institutions or bodies wished to make.

Bendall, Densen & Company, chartered accountants, were asked to continue to serve as auditors.

The Chairman thanked Mr. Pearce for his work during the year. Had it not been for Mr. Pearce, he said, there would not have been a British Foundry School.

Dimensional Tolerances for Castings

(*Continued from page* 101.)

Example C.—4$\frac{3}{4}$ in. dimension shows approx. $\frac{3}{8}$ in. per ft. contraction, while 1$\frac{1}{64}$ in. dimension actually shows $\frac{1}{16}$ in. per ft. expansion.

Example D and E.—In each case contractions as high as $\frac{1}{8}$ in. per ft. are shown on several dimensions.

Example F.—16$\frac{13}{32}$ in. dimension shows a contraction of approx. $\frac{3}{32}$ in. per ft., but 3$\frac{1}{16}$ in. dimension shows $\frac{1}{16}$ in. per ft. expansion.

Example G.—A contraction of 1$\frac{1}{8}$ in. on a length of 49$\frac{1}{32}$ in. represents a contraction of about $\frac{3}{32}$ in. per ft., in spite of the rapping which a floor moulded job may be assumed to have had.

It will thus be appreciated that a job calling for great accuracy may involve quite a large amount of experimental work before the pattern can be passed into production. The difficulty in producing accurate castings (bearing in mind this question of contraction as related to design and production methods used) is therefore emphasised when executing small quantities, or when working a customer's pattern, made to a contraction rule.

A further variable is introduced by the expansion of the castings in the annealing process. This is illustrated by the data in Table II.

(*To be concluded.*)

Carbon and Molybdenum Steels at High Temperatures

At the Chemical Engineering Congress of the World Power Conference, held in London recently, Messrs. C. H. M. Jenkins, H. J. Tapsell, G. A. Mellor and A. E. Johnson presented a Paper on "Some Aspects of the Behaviour of Carbon and Molybdenum Steels at High Temperatures." We append the authors' conclusions.

Summary

The increase in working temperatures in high-pressure steam plant calls for materials capable of resisting stress at high temperatures, of retaining their strength for long periods, and of resisting chemical attack by air, flue gases, and super-heated steam. The work undertaken at the National Physical Laboratory on behalf of The British Electrical and Allied Industries Research Association covers an examination of the behaviour of carbon and low-alloy steels under these conditions. Thirteen carbon steels have been tested at 450 deg. C. under a load of 8 tons per sq. in. The indications are that in the wrought condition the 0.4 per cent. carbon steel has lower strength at 450 deg. C. than the 0.15 per cent. carbon steel, the reverse of the effect at atmospheric temperatures. Three steels, of known origin and manufacture, containing 0.16, 0.19 and 0.40 per cent. of carbon respectively, showed an abnormally low resistance to creep. The cause of the abnormality is not completely clear.

Heat-treatment causing spheroidisation of the cementite lowers the resistance to creep, whilst coarsening the ferrite grain increases it; the effects are more noticeable in the 0.4 per cent. carbon steels.

Steels of similar carbon contents, with the addition of 0.5 and of 1.0 per cent. of molybdenum, have been examined in the same way. These steels are markedly affected by heat-treatment. For the steel containing 0.11 per cent. of carbon and 0.5 per cent. of molybenum the oil-hardened and tempered condition is the most resistant to creep. A coarsened structure is more resistant than that of a steel cooled in air from just above the normalising temperature, whilst a spheroidising treatment greatly reduces the resistance, the creep rate of a spheroidised steel with 0.11 per cent. of carbon and 0.52 per cent. of molybdenum at 550 deg. C. under a load of 9 tons per sq. in. is 80 times that of the oil-quenched and tempered specimen. Heat-treatment at 550 deg. C. for 4 months before applying the load caused a slight improvement in resistance. With a steel containing 0.4 per cent. of carbon, however, oil-quenching and tempering reduces the creep resistance below that of the air-cooled condition.

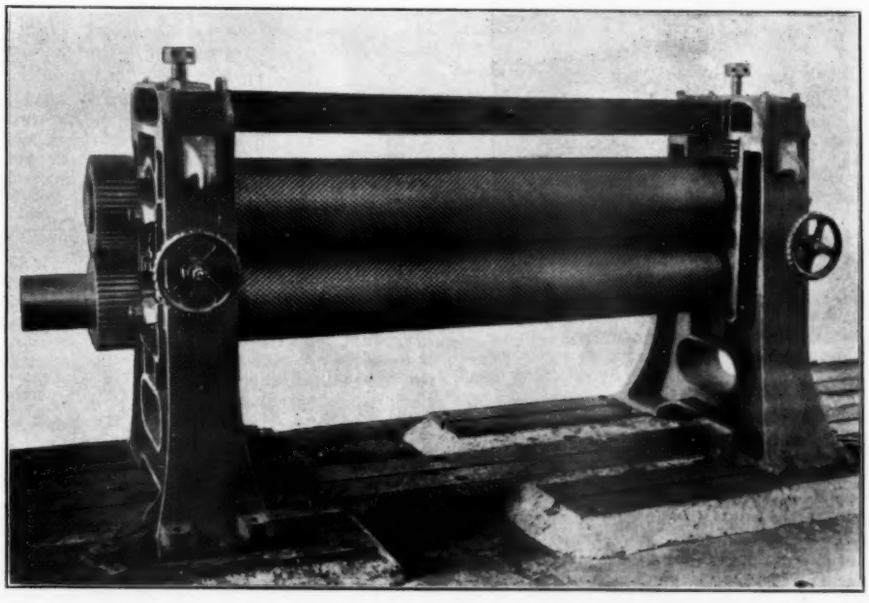
Probably for most steels at elevated temperatures, if the stress is comparatively high and the times of stressing sufficiently long, failure ultimately occurs by intercrystalline cracking. The mechanism of this type of failure has been studied in detail for molybdenum steel. Experiments are in progress to determine whether cracking is likely to occur in 100,000 hrs. (about ten years) when the conditions are such that the total extension is less than 1 per cent. The effect of adding other alloying elements to the molybdenum steels is also being studied.

Little difference is found in the rate of corrosion of the several steels in a synthetic flue gas containing 0.04 or 0.07 per cent. of sulphur dioxide, but the attack is much more rapid at 600 deg. C. than at 500 deg. C. Superheated steam also attacks all the steels at about the same rate. In both instances the texture of the scale produced is an important factor, and this subject, including the difference between continuous and intermittent exposure, is being examined.

Paper Indenter Rolls of Nickel Cast Iron

Our illustration shows a nickel cast-iron indenter manufactured by a well-known American firm of paper-machinery builders. The rolls are produced by first machining to true cylindrical shape and then cutting grooves lengthwise and around the cylinders. Alternate pegs in each line are then removed so that when assembled each peg contacts an opposing indentation.

With ordinary cast iron, the danger of uncovering soft spots or open-grained porous metal when projections are cut would be considerable. Three per cent. nickel cast iron was therefore used so that the resulting metal should be dense and readily machinable. In addition to providing a thicker layer of close-grained metal, thereby facilitating production, this material has excellent wear-resisting properties, and hence the life of the rolls is considerably lengthened.



Indenter Rolls, used in Paper and Pulp Mills, of 3 per cent. Nickel Cast Iron.

Opacifiers in Wet and Dry Enamels*

By Dr.-Ing. LUDWIG STUCKERT (Technische Hochschule, München)

At the meeting of the Verein Deutscher Emailfachleute (German Enamel Technologists' Association) in 1933, the author tried to show on theoretical grounds how the effect of the various opacifying media depends on the refractive index, the number of opacifying layers, and the particle size of the opacifying materials.[1] As a preliminary to the systematic investigation of the many problems then revealed, an experimental comparison of different opacifiers under identical conditions has now been undertaken. In the course of this work it has been shown, however, that the effect of the opacifying agent added to the mix is not confined to optical differences, but goes far deeper than is commonly assumed.

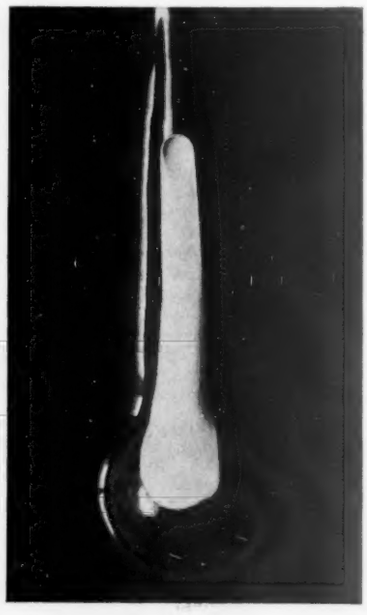


Fig. 1.

Accordingly, some of the physical and chemical changes produced in the melt by different opacifiers have been investigated.

The literature contains little information regarding the influence of opacifiers on the properties of the enamel, and the existing data refer almost entirely to the opacifier in the molten state. Thus Vielhaber[2] showed that the addition of up to 3 per cent. of stannic oxide increases the fusibility of the enamel, although further addition of stannic oxide raises the melting temperature. Kirk[3] has also found a similar effect of stannic oxide on the fusion temperature of the enamel. It is stated in the author's book "Die Emailfabrikation," that when melted in, stannic oxide influences favourably the thermal and elastic properties of the enamel, but scarcely affects these properties if it is employed as an addition to the mill. The latter part of this statement is no longer tenable according to the present work, and requires complete revision. Not only as an addition to the melt, but also when added to the mill, stannic oxide has a great and entirely favourable influence on the properties of the enamel. The other opacifiers as mill additions also exert definite effects on the underlying enamels, producing measurable changes in their properties.

The technical literature of enamel has hitherto concerned itself little with the oldest and most outstanding opacifier, stannic oxide. This is largely due to its universal applicability, which appeared to make the investigation of stannic oxide enamel superfluous, while with all substitute opacifiers the competition with stannic oxide necessitated a determination of the best conditions for their application.

As regards the optical effect of opacifiers, the work of Danielson and Frehafer[4] may be considered as fundamental, according to which stannic oxide occupies the leading position in Group A (group of good opacifiers). The present work fully confirms this verdict. In personal theoretical studies of opacity[5] the author has assumed that the optimal scattering effect is obtained with a particle size of about 1μ. In confirmation of this view, Germscheid[6] has reported that satisfactory commercial varieties of stannic oxide for this purpose possess a particle size of 0.8 to 1.0μ, only about 15 per cent. of all particles having a diameter between 1.0 and 1.2μ. Which stannic oxide—that produced by oxidation of molten tin or of tin vapour—best corresponds to these particle sizes is still an open question.[7]

A Paper by Andrew, Clark and Alexander[8]

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2 "Zusammensetzg. d. Emailglasuren," p. 21.
3 J. Amer. Ceram. Soc., 1932, **15**, 226.
4 J. Amer. Ceram. Soc., 1923, **6**, 634.
5 L. Stuckert, *loc. cit.*, p. 218.
6 "Emall. Ind.," 1933, **10**, 413.
7 R. Kahl, "Keram. Rund.," 1933, **41**, 267; see also *ibid.*, 1933, **41**, 199.
8 J. Amer. Ceram. Soc., 1931, **14**, 634.
9 "Chem. Ind.," 1900, **23**, 108.
10 Trans. Ceram. Soc., 1911–12, **11** (1), 118.
11 J. Amer. Ceram. Soc., 1929, **12**, 188.
12 Cf. H. Hecht and B. Oldenburg, "Keram. Rund.," 1935, **43**, 263.
13 "Emall. Ind.," 1936, **13**, 59.
14 "Glashütte," 1935, **65**, 705.
15 Prüfungsmethoden f. emaillierte Gegenstände, "Emallwaren-Ind.," p. 18.

Table I.—*Compositions of Enamels Used.*

Enamel mixture.	A.	B.	C.
Quartz	190	170	230
Felspar	325	350	300
Borax	243	250	430
Soda	30	25	30
Potassium nitrate	91	100	40
Fluorspar	—	—	60
Cryolite	122	75	60
Marble	27	40	—
Antimony trioxide	—	—	40
Calculated analysis	**Per cent.**	**Per cent.**	**Per cent.**
SiO_2	47.80	49.00	44.60
B_2O_3	10.60	11.30	16.50
Al_2O_3	7.08	7.90	5.75
CaO	1.80	2.76	—
CaF_2	—	—	6.29
K_2O	11.50	12.94	7.20
Na_2O	6.72	6.85	9.20
Cryolite	14.50	9.25	6.29
Sb_2O_3	—	—	4.20

Table II.—*Coating Power of Enamel A.*

Experiment No.	Opacifier.	Per cent. addition to mix.	Cm. length of outflow.	Remarks.
20	—	0	13.8	Enamel runs and must be thickened.
21	SnO_2	2	11.4	Addition of stannic oxide causes immediate stiffening and gives, with increasing additions, good and uniform coating power.
22	,,	6	9.8	
23	,,	9	9.2	
24	,,	12	8.5	
25	"W"	2	14.0	Stiffening is appreciably less than with stannic oxide. The enamels must first be thickened and are capable of coating only after larger additions of "W."
26	,,	6	12.4	
27	,,	9	11.9	
28	,,	12	11.0	
29	"X"	2	12.8	Stiffening is at first considerably less than with stannic oxide. With larger additions the enamel is workable without a thickening agent.
30	,,	6	10.5	
31	,,	9	10.5	
32	,,	12	10.5	
33	"Y"	2	22.0	Enamels run strongly and must be thickened for working. The consistency seems to pass through maxima and minima according to the *p*H of the slip.
34	,,	6	19.2	
35	,,	9	19.9	
36	,,	12	18.3	
37	CeO_2	2	23.5	
38	,,	4	19.0	
39	,,	6	20.7	
40	"Z"	2	10.1	Enamel on limit of workability.
41	,,	4	9.0	
42	,,	6	9.0	
—	Normal white.	—	10.1	Normal coating enamel from technical practice.

* Translated by the International Tin Research and Development Council from a Paper presented to the Verein Deutscher Emailfachleute, Leipzig.

reports on the state in which stannic oxide is present in an enamel frit. On the basis of X-ray investigations, they come to the conclusion that stannic oxide opacifies only as such, and not, as Zulkowski[9] assumes, through the precipitation of complex stannates of the type $K_2O,2SnO_2$. The opacifying stannic oxide remains entirely undissolved. The data of Lomax[10] conflict with this to a certain extent, however. It is probable that the greater part of the stannic oxide remains as such, and acts as an opacifying agent in the melt through its fine subdivision. Small amounts certainly enter the melt, however, since the effects of stannic oxide described later, and those of other opacifiers, cannot otherwise be explained.

The present work aims, in the first place, at purely practical requirements. It may be divided accordingly into the investigation of the influence of the opacifier on the coating power of the enamel; its bending strength and heat resistance; its solubility on extraction with dilute

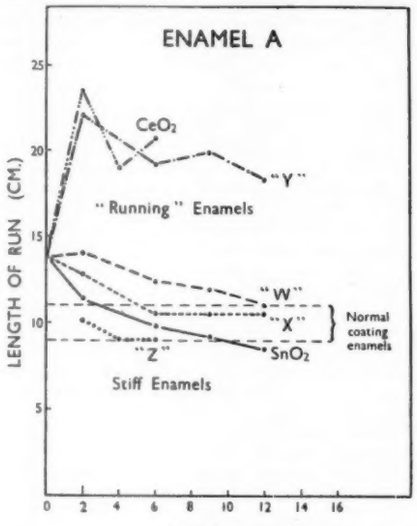

Fig. 2.—Coating Power of Enamels.

acids; and the opacity and lustre after normal burning and overburning. The effect of opacifiers has been investigated with both wet and dry enamels.

Influence of Opacifiers in Wet Enamel

The investigation includes a series of opacifiers used in practice, viz., (1) pure commercial stannic oxide, as powdered ordinarily for enamelling purposes; (2) admixed stannic oxide, as found in commerce under a trade name and referred to hereafter as "W"; (3) a typical mixed opacifier, referred to later as "X," which consists of sodium meta-antimonate 11.6 per cent., stannic oxide 8.7 per cent., kaolin or clay 10.0 per cent., with 73.5 per cent. of a frit of glass, borax and cryolite; (4) various sodium meta-antimonates, both pure and as found in commerce under various trade names (referred to later as "Y.") These consist, with one exception, which contains about 13 per cent. of filler, of meta-antimonate with small amounts of antimonite; (5) pure cerium dioxide; (6) a gas opacifier referred to later as "Z," which is applied in conjunction with a definite enamel and a corresponding clay.

The materials were obtained through an enamel works, in order to be sure that ordinary commercial products were used in the investigation. It was originally intended to test a zirconium opacifier, but this had to be abandoned, since it is no longer produced for wet enamelling, and has been apparently replaced completely by the gas opacifier.

Three enamel mixtures served for comparison of the opacifiers in wet enamel; namely, an enamel A, moderately pre-opacified with cryolite; a transparent enamel B; and an enamel C, strongly pre-opacified with melted-in antimony trioxide. The compositions and analyses of these enamels are given in Table I.

Enamels A and B, which served as bases for the majority of the investigations, were fused in quantities of 5 kg. at a time in an electric furnace at 1,140 deg. C., and the granules of the different partial melts intimately mixed after drying, ensuring that all experiments were carried out with uniform material. Preliminary experiments showed that a fineness of the enamel slip corresponding roughly with technical conditions could best be attained if each enamel were first ground dry in the porcelain ball mill, and then ground finally in a smaller wet ball mill. The granules were ground dry so that one half passed a 1,600-mesh and the other half a 900-mesh sieve without residue. From each of the enamel powders so obtained, 75 grm. were ground for 1 hour with 5 per cent. of clay, varying amounts of opacifiers and 44 per cent. of water in a porcelain ball mill of 1.5 litres capacity, with a 750-grm. porcelain ball. After half-an-hour's grinding the mill was stopped, lid and edge were freed from coarser particles, and grinding was continued for a further half-hour. This procedure gave a slip which was uniform throughout, and which showed 0.6 to 0.7 c.c. sieve residue according to the Pemco fineness test. Since with increasing amounts of opacifier the enamels become too stiff, the amount of water was also increased each time, so that it always amounted to 44 per cent. of the solid portion. The mill charge was thus always as follows:—

75 grm.	... ...	enamel/900-mesh
75 ,,	.. ...	enamel/1,600-mesh
7.5 ,,	... ...	Vallendar clay
0-18 ,,	... ...	opacifier
66-74 c.c.	... ...	distilled water

The slip thus produced had a constant ratio of solid to water, a constant fineness of grinding, and a consistency and coating power that depended on the opacifier alone. After the final milling the enamels were filled into stoppered glass bottles of about 150 c.c. capacity and kept for 48 hours, after which they were shown to be constant in coating power, etc.

Dependence of Coating Power of Enamel *A* on the Opacifier

Superficial examination alone revealed considerable differences in the consistency of the slips made with different opacifiers. With almost all slips the viscosity increased fairly uniformly with increasing addition of opacifier, although the ratio of solid residue to water remained constant in all cases. As a measure of the coating power of a slip, the Americans have adopted the plasticity, and determined this by the Bingham out-flow or the Gardner mobilometer methods. In Germany the Pemco dipper method, improved by Vielhaber, has been adopted to a greater extent. It was at first used in this work also for the measurement of consistency. Since only relatively small amounts of slip were available, a small dipper of only 75 sq. cm. area had to be used. It at once appeared, however, that while the reproducibility of the values lay within 6 to 10 per cent. of the mean, the trend of the values so found did not accord with the superficially observable changes in viscosity. The method was, moreover, too lengthy, especially when, to improve the reproducibility of the results, the dipper was dried after dipping into the enamel and the adhering slip weighed. This weight amounted on the average to 1.7 grm., which would correspond to about 13 grm. of moist slip with the Vielhaber dipper. This value agrees well with the figure 12 grm., usual in practice.

For the more accurate comparison of coating power with the small amounts of slip available, a procedure similar to the outflow method was more suitable. Instead of measuring the time of flow of the slip, however, the length of path traversed by a definite constant amount of enamel was determined, the apparatus being arranged vertically. The method is similar to the determination of the fusibility of enamel by measurement of the length of the drop of melt formed. This method of working proved surprisingly rapid to carry out, and yielded results agreeing within 2 to 6 per cent., and varying only 1 to 3 per cent. from the mean. In a metal sheet, 1.5 mm. thick, 25 cm. long, and about 8 cm. wide, a depression about 3 cm. in diameter was formed, which ran out into a tapering groove. (See Fig. 1.) A ground enamel was applied to the whole. Two grm. of slip were weighed out each time into the depression, the plate was placed vertically, and the length of the path of flow measured when the flow of enamel became stationary. The mean of four experiments gave the final result. The values of these measurements are collected in Table II, and reproduced graphically in Fig. 2. The individual enamels were judged in comparison with practical conditions by obtaining from an enamel works a white for double coating, the

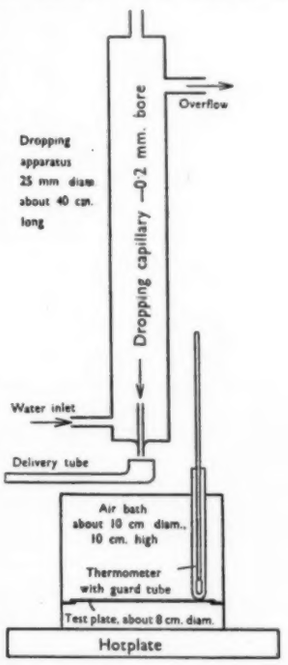
Dropping apparatus 25 mm diam about 40 cm. long
Overflow
Dropping capillary —0·2 mm. bore
Water inlet
Delivery tube
Air bath about 10 cm diam., 10 cm. high
Thermometer with guard tube
Test plate, about 8 cm. diam.
Hotplate

Fig. 3.—Dropping Apparatus for Determining Heat-Resistance of Enamels.

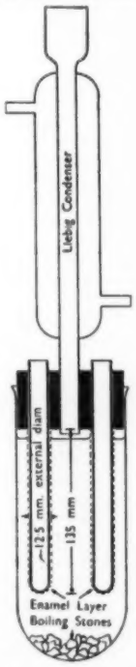

Fig. 4.—Apparatus for Determining Solubility of Enamels.

flow length of which lay in the middle region. As may be seen, this field of normal coating enamel is a relatively narrow one. Above it is the region of "running," and below it that of the stiff enamels. In the former lie the slips prepared with the addition of meta-antimonate and cerium oxide, which run strongly throughout, and must be thickened. The region of the stiff enamels contains only the slip with high stannic oxide content, which for technical use must be diluted to some extent. In the field of normal coating ability lie also the slips with gas opacifier. These are based on an incompletely fused enamel, which by itself is stiff, and becomes stiffer still on addition of the opacifier. The consistency curves of the enamel slips prepared with stannic oxide are the most regular. All the enamel slips containing technical amounts (between 2 and 10 per cent.) of stannic oxide obtained lie in the zone of normal coating power. Thickeners are also superfluous in normal working, thus avoiding the possibility of faults which are often to be attributed to their use. With the admixed stannic oxide, an effect of the filler is clearly perceptible. The enamels tend to run, especially with low additions of opacifier. With the mixed opacifier, which consists chiefly of a fused frit, various opposing influences appear to

be at work, so that the coating power of the slip is normal over a wide range. Enamels containing cerium dioxide or antimony trioxide are remarkable for the sudden alterations of viscosity of the slip observed with high additions of opacifier. These changes are probably produced by small amounts of electrolytes, which adhere to, or are produced by, hydrolysis of the opacifiers, in a similar way to the known influence of sodium hydroxide of different concentrations on clay slips. Thus, stannic oxide slips have outstanding advantages from the viewpoint of working properties.

Table III.—*Flexibility of Enamel.*

Opacifier.	Per cent. addition to mix.	Enamel A. Breaking load, kg.	Enamel A. Deflection, mm.	Enamel B. Breaking load, kg.	Enamel B. Deflection, mm.	Enamel C. Breaking load, kg.	Enamel C. Deflection, mm.
—	0	28.5	16.5	31.0	22.0	23.0	19.0
SnO_2 ..	2	29.0	17.7	No breakage		28.0	22.0*
„ ..	4	No breakage		—	—	No breakage	
„ ..	6	„		No breakage		—	—
„ ..	9	„		—	—	—	—
„ ..	10	—	—	No breakage	—	—	—
„ ..	12	No breakage	—	—	—	—	—
"W" ..	2	27.0	16.5	25.0	19.5	—	—
„ ..	6	24.0	17.0	28.5	19.0	—	—
„ ..	9	23.5	15.8	—	—	—	—
„ ..	10	—	—	28.5	20.0	—	—
„ ..	12	21.5	13.0	—	—	—	—
"X" ..	2	21.8	16.5	24.5	20.0	—	—
„ ..	6	23.0	14.4	23.5	17.0	—	—
„ ..	9	21.3	17.0	—	—	—	—
„ ..	10	—	—	23.5	14.5	—	—
„ ..	12	21.8	13.3	—	—	—	—
"Y" (for enamel B)	2	25.5	15.8	32.5	17.0	—	—
	6	24.0	18.3	31.0	17.0	—	—
	9	26.0	17.5	—	—	—	—
	10	—	—	26.5	16.0	—	—
	12	25.0	18.0	—	—	—	—
CeO_2	2	26.3	15.0	No breakage	—	26.0	21.0
„	4	8.0	15.9†	24.5	19.5	—	—
„	6	16.0	11.5†	—	—	—	—
"Z" ..	2	26.5	12.0	—	—	—	—
„ ..	4	24.0	13.0	—	—	—	—
„ ..	6	17.5	6.0	—	—	—	—

* Broke only on prolonged standing under load. † Somewhat "boiled out."

Bending Strength of the Enamel

Bending strength was determined on the Amsler machine, which Professor Huber of the Mechanical-Technical Laboratory of the Technische Hochschule, Munich, kindly put at the author's disposal. Seven grm. of enamel slip were spread uniformly, and burned in. The strips were then laid symmetrically on two steel knife edges 10 cm. apart, and slowly deflected in the machine by a steel knife edge, acting in the middle. The load was measured on a drum with tenfold magnification, and the deflection (in mm.) on a scale attached to the machine. The accuracy of the determination of the breaking-load was about ± 0.2 kg., which, with the breaking loads in question, amounted to 0.5 to 1 per cent. of the effective load. By a vernier, or by estimation, the deflection may be determined to ± 1 per cent. of its value. The results of these measurements are given in Table III, from which the following conclusions may be reached.

Enamels containing gas opacifiers show normal breaking strength when normally fired; but when overfired the breaking strength is reduced to a low value. All the solid opacifiers, except stannic oxide, reduce the bending strength of the enamel more or less. This influence is strongest with the mixed opacifier, "X," which reduces the breaking strength of both enamels A and B by about 25 per cent. Antimonates also produce a lowering, as does "W." Here the unfavourable effect of the filler with increasing proportion of the opacifier is clearly perceptible.

Stannic oxide occupies, however, a special place. With only 2 per cent. addition, no breakage occurred with enamel B, which by itself is already highly resistant towards bending. Even with the mixtures which incline more to breakage, such as enamel C, the breaking strength is raised, and with only 4 per cent. addition of stannic oxide to the mill, breakage is eliminated. The same effect is observed with enamel A; from 4 per cent. of stannic oxide upwards, the enamels are resistant to breakage. The favourable effect of stannic oxide on a mechanical property of the enamel does not appear to have been quantitatively investigated before. The causes of this effect will be discussed later.

Thermal Resistance of Enamel

From the foregoing, it is to be expected that the thermal resistance of the enamel would also be influenced by the addition of opacifier to the mill. The measurement of this property was carried out by means of the dropping apparatus described by Kinzie,[11] which is represented schematically in Fig. 3. Every ten seconds for 15 minutes a drop of water falls from a capillary on to the same point of the test plate, heated at 360 deg. C. The quality of the enamel is judged from the appearance of the spot on which the drops fall, after making the fine cracks and fissures visible by means of ink or lamp black. The results obtained by this means with enamels A, B and C and the various opacifiers may be summarised as follows: the pure, unadulterated opacifiers, especially stannic oxide and sodium meta-antimonate, up to additions of about 6 per cent., increase the thermal strength of the enamel. The increase is not very great, but is clearly perceptible. Above 6 per cent. of opacifier the thermal strength falls again. Admixed opacifiers, such as "W" or "X," reduce the thermal strength of the enamel considerably, even with very small additions. Cerium dioxide as an addition to the mix increases the tendency to crack. A special enamel with "Z" was removed in large flakes even after about 5 minutes' dropping. The cause appeared to be due to a too refractory ground coat; with a suitable ground coat the thermal resistance is satisfactory. With enamel C the resistance to thermal shock is less than with A and B; the dropping spot is crossed by fairly large cracks, and on standing the upper layers of enamel flake off. In this case there is no improvement with the embedded opacifiers, in the author's case stannic oxide and cerium dioxide, since the low thermal resistance of the enamel itself cannot be perceptibly improved by the minimal additions of opacifier.

Table IV.—*Acid Solubility of Enamel.*

Opacifier.	Per cent. addition to mix.	Solubility in 10 per cent. acetic acid. (mg. per 50 cm.² surface) Enamel A.	Solubility in 10 per cent. acetic acid. (mg. per 50 cm.² surface) Enamel B.	Solubility in 4 per cent. tartaric acid. (mg. per 50 cm.² surface) Enamel C.	Sb_2O_3 per 50 cm.² surface Enamel C.	Solubility in 1 per cent. acetic acid (mg. per 50 cm.² surface) Powder enamel.
—	0	66.4	74.0	275.4	2.38	—
SnO_2	2	38.2	37.1	237.2	1.75	—
„	4	—	—	243.3	1.75	—
„	6	31.3	27.3	—	—	—
„	9	30.5	—	—	—	—
„	10	—	23.9	—	—	—
„	12	29.0*	—	—	—	—
"W" ..	2	51.2	—	—	—	—
„ ..	6	39.9	36.0	—	—	—
„ ..	9	41.4*	—	—	—	—
„ ..	10	—	27.1	—	—	—
"X"	2	56.6†	—	—	—	—
„	6	56.6†	66.5†	—	—	—
„	9	53.7†	—	—	—	—
"Y"	2	51.3†	—	—	—	—
„	6	48.7†	34.3†	—	—	—
„	9	44.7†	—	—	—	—
CeO_2	2	49.6	—	—	—	—
„	4	41.0	37.4	250.3	1.90	—
SnO_2	—	—	—	—	—	138.9
"Y" ..	—	—	—	—	—	128.7
„	—	—	—	—	—	128.8

* The acid gives with H_2S a slight yellowish cloud, apparently of stannic sulphide.
† The acid gives with H_2S a reddish precipitate of antimony sulphide.

Degree of Attack of Enamels by Acids

In practice the degree of attack of enamels by dilute acids is usually regarded as a property

(*Continued on page* 110.)

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Opacifiers in Wet and Dry Enamels

(*Continued from page* 108.)

of the enamel mixture used, and when the acid solubility is too high it is natural to seek to remedy the enamel composition. This is readily comprehensible, for it would not be expected that the enamel would be so influenced by an inert opacifier during the short time of burning-in that it would differ markedly in solubility from an enamel not mixed with an opacifier. Here also the experimental investigation of the influence of opacifiers, added to the mill, has provided an unexpected and surprising result. As regards the method of the extraction experiments, the Gries test was, of course, completely excluded. The solubility could only be tested on finished, fired enamels. The methods previously proposed in the literature for determining the degree of attack of beakers, dishes or plates by weighing the evaporation residue of the acid were also avoided. On the one hand, this procedure defines the size of the attacked area insufficiently sharply, and on the other hand the evaporation of the solutions requires platinum vessels, takes a long time, and is not trustworthy, since extracted boric acid volatilises strongly with the water and acid vapours.

It was attempted, therefore, to determine the degree of attack by measurement of the loss in weight of the enamelled test body, whereby the problem resolved itself simply into the discovery of a suitable test body, which could readily be freed from all adhering traces of the extracted solute after the acid treatment, which could be weighed accurately on the analytical balance, and which above all presented a constant surface of attack to the acid. A suitable test specimen was found to be an iron tube, 175 mm. long and 10 to 11 mm. outer diameter, which was welded down one side and made hemispherical at one end.[12] The tubes were ground-enamelled in the works, and the different coating enamels applied by pouring. After some practice, it was readily possible to distribute the enamel so uniformly over the surface that accumulations on the hemispherical end were avoided. Occasionally it was advisable to dry the enamel over a gas flame to stop excessive running to the lower parts. At the open end of the tube a 25 to 30 mm. band remained free from coating enamel, where the number of the experiment could be marked with coating enamel and burnt in, so as to avoid confusion of the individual test tubes.

After drying, the enamels were fired in an electric muffle furnace at 850 deg. C. A double coating was generally found sufficient to obtain a completely continuous, uniform covering. Only strongly "running" enamels were applied in a threefold layer. After cooling the fired tubes in a desiccator, they were weighed on an analytical balance to 0.2 mg., and then subjected in pairs to acid extraction in the simple apparatus shown (Fig. 4). At least two extraction tests were carried out on each enamel slip. The test tubes were passed so far through suitable holes in a rubber bung that a part of the coating enamel was still covered by the rubber, and the enamel area exposed to the acid attack was 50 sq. cm. Through the third hole of the bung passed a short Liebig condenser, which ended flush with the lower side of the bung. The whole was fitted on to a tube of Jena glass 40 mm. wide, 180 mm. long, and filled with acid through the condenser to within about 1 cm. of the bung. A few pieces of porous tile were inserted to prevent bumping during the subsequent boiling. As test acids, 10 per cent. acetic acid was used for the sheet enamels A and B; 4 per cent. tartaric acid for enamel C; and 1 per cent. acetic acid for the powder enamel to be discussed later. The acids were rapidly brought to boiling, and after the appearance of the first vapour bubbles kept gently boiling for 1 hr. The liquid thereby covered the whole free enamel surface, and rose to some extent in the water-cooled condenser, which, however, in no way interfered.

At the end of the experiment the tubes were thoroughly washed with warm water, and freed from all loose adhering particles with the aid of a soft sponge. They were then rinsed with alcohol and dried for 1 hr. at 105 to 110 deg. C. The tubes were cooled in a desiccator and weighed in a suitable weighing tube, since the corroded enamels are hygroscopic and the test tubes increase in weight slightly on the balance. The results obtained proved to be highly concordant and reproducible throughout. They varied, for different tubes with the same coating enamel, generally by 1 to 2 per cent. about the mean. Table IV gives the extraction figures, which are reproduced graphically in Fig. 5.

It will be seen that all the opacifiers diminish the solubility of the enamel. This reduction is smallest with the mixed opacifier "X," which indeed introduces practically nothing except glass into the slip. Then follow, in order of increasing efficiency, the antimonates, admixed stannic oxide, cerium oxide, and finally stannic

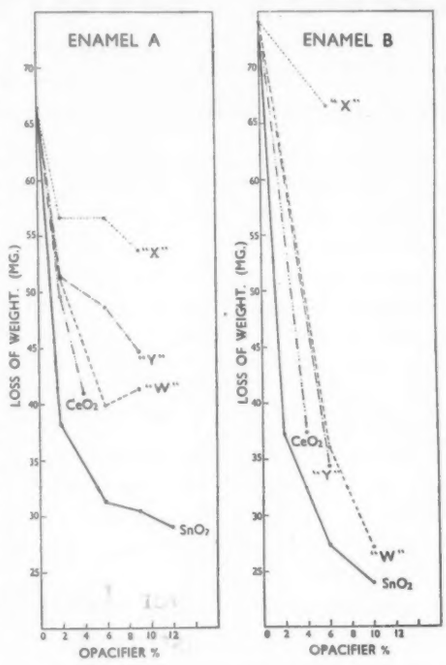


FIG. 5.—ACID SOLUBILITY OF WET ENAMELS.

oxide. By the use of the last the degree of attack is most effectively diminished. With enamel A it amounts finally to only one half, and with enamel B only one third of the original value. Such favourable action is attained by no other opacifier. The origin of the effect can, for the present, be only suspected. Probably, during the short firing period interactions occur between enamel and opacifier, and the former is brought nearer the equilibrium position through the addition of stannic oxide, whereby its solubility is reduced. The chemical behaviour is thus completely analogous to the mechanical behaviour, where by the use of stannic oxide a very considerable improvement of the enamel was established. Again, fillers of any kind also greatly reduce the influence of the opacifier on the acid solubility; for example, it is more strongly reduced by the addition of 2 per cent. of pure stannic oxide than by 6 per cent. of "W." The fillers thus counteract to a great extent the beneficial effect of the stannic oxide on the resistance to acids. The solubility of enamels A and B amounted to 0.6 to 0.8 mg./sq. cm., agreeing well with the values customary in technical white enamelling.

After this work was concluded, a publication by Kerstan[13] appeared which dealt also, in Section 7, with the influence of opacifiers on acid solubility of enamel. Kerstan also found an improvement in the chemical resistance of enamel by adding stannic oxide and "Leukonin," which he attributed to the insolubility of the two substances in acids. He concludes therefrom that the opacifiers are not dissolved in the enamel, but are only in suspension. Personal opinion is, however, that the favourable effects of opacifiers on the properties of the enamel cannot be explained without assuming a partial, if only limited, dissolution in the melt. It does not seem justifiable to draw such far-reaching conclusions from the acid solubility of enamel only, as Kerstan does. As far as Leukonin is concerned the results disagree with those of Andrew, Clark and Alexander.

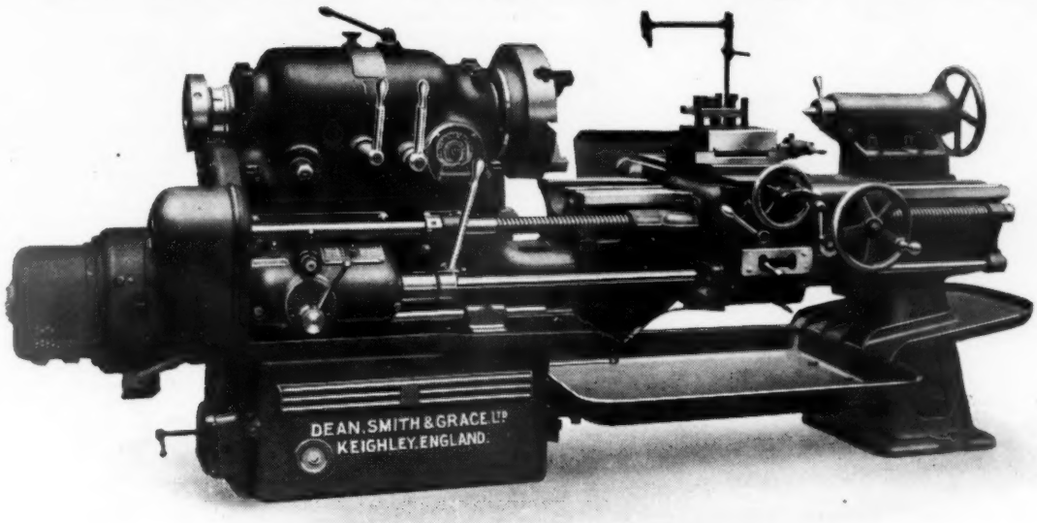
With enamel C, which was treated with 4 per cent. tartaric acid, a decrease in acid solubility was also obtained after mill additions of stannic oxide or cerium dioxide. The decrease amounts to only 12.7 per cent. for stannic oxide, and to only 9.1 per cent. with cerium dioxide. In this case the attacking acid is too potent in its action to be much influenced by the small additions of opacifier. The opacifiers also exert an effect, however, on the amount of dissolved tervalent antimony. The amount of Sb_2O_3 was reduced by 26.5 per cent. with stannic oxide, and by 20.3 per cent. with cerium dioxide. Lang[14] has recently stated enamels pre-opacified by melting-in antimony trioxide and opacified with cerium dioxide to be the best, as is already known in the enamel industry. On the other hand, Karmaus[15] in his address to the meeting of the Verein Deutscher Emailfachleute in 1931 has indicated that it is not desirable to use enamels pre-opacified with antimony trioxide for coating household ware. With reference to the loss of tervalent antimony determined above, it may be remarked that this loss refers to a surface of 100 sq. cm. On a vessel of 1 litre capacity there will be 400 to 500 sq. cm. surface, *i.e.*, an extraction of 11.9 mg. of Sb_2O_3. Even under the influence of stannic oxide this loss is reduced only to 8.8 mg., which exceeds very considerably the proposed maximum of 3 mg. per litre capacity. Such enamel cannot be considered, therefore, for cooking vessels, and must be limited to other applications, such as sanitary articles, etc.

A special enamel, based on "Z," has a rather higher acid resistance than melts A and B, and the enamels obtained from them. The mean solubility of this enamel determined with 10 per cent. acetic acid, was only 26.0 mg. per 50 sq. cm. The enamel is thus more resistant than the mixes A and B used for comparison with solid opacifiers. It is possible, of course, to use such hard and acid-resistant enamels with solid opacifiers, especially with stannic oxide; they probably need only a rather higher addition of opacifier.

(*To be concluded.*)

A NEW CONCERN with an authorised capital of £50,000 has acquired from M. & B. Investments, Limited, the business carried on by them under the style of Mason & Burns, Limited, at Moat Foundry, Pleck Road, Walsall. The business was formerly carried on by W. Mason & Company, Limited, malleable ironfounders, and was incorporated as Mason & Burns in 1922. The name of this company has recently been changed to M. & B. Investments, Limited, and the new company will carry on the business under the style of Mason & Burns, Limited. The purchase price is £61,667 to be satisfied as to £45,000 in cash and by the allotment to the vendors or their nominees of 166,667 ordinary shares of 2s. The working capital of the new company at June 30, 1936, amounted to £21,178, and is considered by the directors as sufficient for the purpose of its business. The profit of the old company in 1935 was £12,387, and the estimated net profit for the year ended June 30 last is £11,397, stated to be almost 23 per cent. on the share capital.

For Heavy Engineering Castings



FOR heavier types of engineering castings, such as those used in lathes, Stanton Low Phosphorus Foundry Pig Iron is particularly suitable. It can be supplied within limits of 0.25% margins of silicon.

The Super High Speed Production Lathe illustrated above is by Dean, Smith & Grace, Limited, of Keighley, who are regular users of

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The largest Producers of Foundry Pig Iron (for Sale) in Great Britain

Graph. Carbon %	Comb'd Carbon %	Total Carbon %	Silicon %	Sulphur %	Phos. %	Mang. %
3·35	0·35	3·7	2·5–3·5	0·03–0·05	0·73–0·78	0·9–1·0

The Stanton Ironworks Company Limited, Near Nottingham

The Week's News in Brief

Trade Talk

BUTTERS BROS. & COMPANY, crane makers, are extending their works at Kinning Park, Glasgow, and are also building a factory at Chiswick, London.

M. COCKBURN & COMPANY, LIMITED, Gowan Bank Ironworks, Falkirk, have been granted permission by the Falkirk Dean of Guild Court to make a considerable extension to their brass shop.

IT IS ANNOUNCED that General Refractories, Limited, now control, through the International Diatomite Company, the freehold works at Colchester owned by Moler Products, Limited, manufacturers of heat-insulating bricks and allied products.

MR. DAVID L. MCCARDEL, general manager of Bairds & Dalmellington, Limited, at Lugar, Ayrshire, opened new playing fields at Lugar and Cronberry recently. The ground was given by the firm to Cumnock District Council for a nominal annual sum of 5s.

ORDERS FOR THREE motor-tankers, valued at £500,000, have been placed with Clyde shipbuilders by the Anglo-Iranian Oil Company, Limited, on behalf of its subsidiary, the British Tanker Company, Limited. Harland & Wolff, Limited, Govan, will build two of the vessels and Lithgows, Limited, Port Glasgow, the other.

IT IS ANNOUNCED that three steel furnaces in the melting shop at the malleable works of the South Durham Steel & Iron Company, Limited, Stockton-on-Tees, are to be started at the end of September, employment being found for between 200 and 300 additional workmen. The melting shop has not been in operation since 1928.

REFERENCE WAS MADE in the House of Commons on July 29 by Sir Samuel Hoare to orders for two new battleships, one of which would be placed with Vickers-Armstrongs on the Tyne and the other with Cammell Laird on the Mersey. The keels will be laid down next January, the earliest date possible under the Washington Treaty.

HURST, NELSON & COMPANY, LIMITED, Flemington Works, Motherwell, have received orders valued at about £150,000 from the L.N.E. Railway. The contracts include one for 500 twenty-ton steel hopper wagons. The firm has also secured an order for 100 fruit-carrying wagons for the San Paulo Railway of Brazil. This is the first contract for rolling stock placed by a South American railway in Scotland for many years.

FOLLOWING the acquisition of the ordinary share capital of the Lanarkshire Steel Company, Limited, by Colvilles, Limited, the board of the former has been reconstituted as follows:—Mr. John Craig (chairman), Mr. James M. Strain, Mr. Henry Lithgow, Dr. A. McCance, Mr. Harry Cunningham and Mr. T. R. Craig. Mr. Strain has for many years been chairman of the Lanarkshire concern, while Mr. Cunningham is chairman of Sir William Arrol & Company, Limited.

PIG-IRON PRODUCERS and importers of ore in the Cleveland area are gravely concerned over the interruption of shipments of iron ore from Spain and Morocco. Since the outbreak of the civil war, Spanish supplies have been completely cut off, and not a single cargo has arrived in the Tees for over a week. Local ironworks have considerable stocks of ore and are also tapping alternative sources of supply, but unless there is a speedy end to the disturbances in Spain the effect on the iron trade will be serious.

THE WORKERS at the Lochaber works of the British Aluminium Company, Limited, who have been on strike, restarted work this week. The firm has agreed to increase the pay to labourers by ½d. per hour, which is double that asked for by the strikers, a ¾d. increase to furnacemen and 5 per cent. advance in piece-rates, and for all workers after one year's employment with the company, commencing from July 30, one week's holiday with pay. The terms are the same as have been accorded to the employees at Kinlochleven works.

THE OUTPUT FIGURES for the Swedish iron and steel industry in the first half of the current year are substantially the same as those for the corresponding period of 1935. The production included:—Pig-iron and primary castings, 282,600 metric tons (against 301,700 tons in January to June, 1935); Bessemer and basic steel, 52,400 (56,400) tons; open-hearth steel, 302,800 (286,400) tons, and crucible and electric steels, 98,700 (87,100) tons. These figures were made up of 205,300 (198,000) tons of high-grade castings and 248,600 (231,900) tons of ordinary castings. Production of rolled and forged products totalled 312,200 (304,800) tons. Of 94 furnaces, 32 were in blast at the end of June, against 34 out of 96 on June 30, 1935; Bessemer converters numbered 7 against 9 out of 14, open-hearth furnaces 48 against 43 out of 72, and electric furnaces 34 against 29 out of 52.

OVER 200 BOYS and several girls assembled in the schoolroom among the foundries and fitting-shops of Mather & Platt, Limited, last Thursday, for one of the most interesting prize-giving ceremonies in the history of Manchester. The prizes are awarded to those who have distinguished themselves in the day continuation school conducted by the firm. Those who attended the ceremony included turners, fitters and erecters—all apprentices at the firm's Park Works at Newton Heath, where they spend two mornings each week during hours in the classroom, taking a course in mathematics, mechanics, machine drawing, English and physical training, and about thirty girls from the firm's offices take shorthand lessons in the evenings. The most promising students are selected to attend the Newton Heath Junior Technical School, and, if they pass certain prescribed examinations, they continue to the Manchester College of Technology. Mr. L. E. Mather, managing director, distributed the prizes of books and boxing gloves, drawing instruments and moulders' tools to eleven boys. Afterwards Mr. George E. Bailey, director and works manager of Metropolitan-Vickers, gave a short prize-day oration, recalling his own apprenticeship days.

Contracts Open

Bradford, August 20.—Special pipes and castings, genuine puddled iron tubing and fittings (steam and gas), wrought iron and steel bars, plates, etc., for the Gas Committee. Mr. G. E. Currier, gas engineer, Britannia House, Bradford.

Johannesburg, August 24.—Gas galvanised iron piping, screwed and socketed, English thread, and ungalvanised malleable iron standard gasfittings, for the South African Railways and Harbours Administration. The Department of Overseas Trade. (Reference T. 30,518.)

Steynton, August 13.—3-in. and 2-in. cast-iron mains, for the Haverfordwest Rural District Council. Mr. D. W. Rees, consulting engineer, National Provincial Bank Chambers, Ammanford. (Fee £2 2s., returnable.)

Patent Specifications Accepted

The following list of Patent Specifications accepted has been taken from the "Official Journal (Patents)." Printed copies of the full Specifications are obtainable from the Patent Office, 25, Southampton Buildings, London, W.C.2, price 1s. each. The numbers given are those under which the Specifications will be printed and abridged, and all subsequent proceedings will be taken.

443,969. BIRMINGHAM ELECTRIC FURNACES, LIMITED, and THOMLINSON, F. Apparatus or appliances for the heat-treatment of metals.

444,004. ROLL, J. Processes for influencing the chemical and physical character of blast-furnace slags.

446,786. OUBRIDGE, W. A. Cast-iron alloy.

446,794. BRITISH THOMSON-HOUSTON COMPANY, LIMITED. Methods of treating silicon steel.

446,866. LAWSON, R. G. Tuyeres.

446,966. WILSON, P. H., RIDLEY, W., and STANTON IRONWORKS COMPANY, LIMITED. Preparation of foundry moulding materials.

447,130. POTTS, H. E. (Haglund, T. R.). Welding of cast iron.

447,211. RIDLEY, W., WILSON, P. H., and COCHRANES (MIDDLESBRO') FOUNDRY, LIMITED, Manufacture of unchilled metallic castings by the centrifugal casting process.

447,244. MARLEY, W. Hot-blast valves for blast furnaces.

Personal

ACCOMPANIED BY HIS WIFE, Coun. W. H. Crosthwaite, director of Dorman, Long & Company, Limited, sailed last Friday for Canada on a health and business trip.

MR. COLIN D. ABELL, metallurgist and analyst, informs us that he has moved into larger and more convenient premises at 1, Woodville Terrace, Horton Lane, Bradford. His telephone number—Bradford 7381—is unchanged.

MR. H. B. ROBIN ROWELL, who has been a director of Messrs. R. & W. Hawthorn, Leslie & Company, Limited, since 1929, has been appointed to succeed Dr. John T. Batey as managing director of the firm's shipbuilding and repairing department, Hebburn-on-Tyne.

Will

CARR, RICHARD WILLIAM, head of Richard W. Carr, steel manufacturers £1,050

Obituary

THE DEATH OCCURRED on July 30 of Mr. Walter Farlan Spencer, managing director of W. F. Spencer, Limited, heating engineers, of Cross Bank Works, Oldham. He was 72 years of age.

MR. GEORGE S. SMITH, partner in George Smith & Son, metal merchants and brokers, died recently. He was chairman of the London Metal Exchange, with which he had been connected for a number of years.

Company Reports

Craven Brothers (Manchester), Limited.—Interim dividend of 5 per cent., less tax, payable on September 30.

William Baird & Company, Limited.—Dividend of 10 per cent., less tax, on the ordinary stock for the year to May 31 last.

Publication Received

Handbook of Information including the Annual Report, 1935-36, and Indexed Lists of British Standard Specifications and Methods of Test. Published by the British Standards Institution, 28, Victoria Street, London, S.W.1. Price 1s.

As the years go by this publication becomes of increasing interest to the foundry executive and incidentally to the industry as a whole. It is of great importance that the co-operative link it forms between Dominion and United Kingdom industries should be strengthened. It renders inter-imperial trading much easier, and thus indirectly facilitates exports. The handbook shows very clearly that quality is not only a function of test-figures, but also is related to dimensional accuracy. It indicates how pathways are smoothed out for co-operation in such matters as the standardisation of sound films, and as the result of an arbitrational award an American standard has been implemented. Amongst specifications in the course of preparation or revision which are of interest to the foundry industry are those for High Duty Grey Iron Castings; Iron Castings for Gear Blanks; White Heart and Black Heart Malleable Iron Castings; General Grey Iron Castings; Brinell Hardness Test; Bend Test; Tensile Testing, and six aluminium alloys.

Heat Treatment in Reheating Furnaces

On the basis of the results of 23 series of measurements on six continuous billet-heating furnaces, operated under varying conditions, J. E. EBERHARDT and H. C. HOTTEL, in the "Transactions of the American Society of Mechanical Engineers," deduce a formula giving the heat-transfer coefficient which has been found in agreement with theoretical calculations and will serve as an aid in designing new reheating furnaces.

B.I. MAGNETIC MOULDING MACHINES

BRITISH PATENTS, 321777, 322728, 349173, 355889

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Each machine forms a complete unit.

Construction and control are simple.

Operating costs are very low. Power is only used during the squeeze operation—approx. 2 seconds. Upkeep costs are very small. There are few moving parts, no glands or packings and no troublesome pipe lines.

If only A.C. is available a relatively small AC/DC convertor is required. A sequence relay device allows of operating a battery of machines from one convertor. Electric vibrators and heaters can be supplied if required. All parts are efficiently guarded against ingress of sand.

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- *and*
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(FOR MALLEABLE CASTINGS OF ALL DESCRIPTIONS)

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TOTAL CARBON	2·70%
SILICON	1·80%
MANGANESE	·90%
SULPHUR	·06%
PHOSPHORUS	·40%

Typical Malleable Pig Iron Specification

TOTAL CARBON	2·60%
SILICON	·75%
MANGANESE	·50%
SULPHUR	·05%
PHOSPHORUS	·06%

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CARGO FLEET · MIDDLESBROUGH

Raw Material Markets

All sections of the iron and steel industry continue to be very active and, owing to the pressure for supplies, the holiday was made as short as possible. However, in many cases works have been idle for a few days in order to carry out urgent repairs. The output of pig-iron is more plentiful and users are having their requirements more easily satisfied. The demand for semi-finished steel is such that it is very difficult to place new business for early delivery, while in the finished steel market there has been a slight slackening in activity, but this is solely due to seasonal causes and a revival is anticipated at an early date.

Pig-Iron

MIDDLESBROUGH.—New business has been slow to materialise in the Cleveland area during the past week, but a few contracts have been arranged for early delivery. It is believed that the deliveries made during July were at least on a level with those of the previous month. The recently increased output in this district has caused a decrease in the tonnage imported from other areas, but there is still a considerable quantity being taken up from the Midlands. Export trade continues to be quiet. It is anticipated that no changes will be made in quotations until after the end of the year. The official minimum prices remain at 75s. per ton for No. 3 Cleveland G.M.B. in the Middlesbrough and Falkirk areas, 77s. on the North-East Coast and 78s. in Glasgow, with 2s. 6d. per ton extra for No. 1 grade and a discount of 1s. per ton for No. 4 foundry and No. 4 forge iron.

Users of East Coast hematite are endeavouring to renew contracts for long periods ahead in view of the possibility of further increases in prices owing to the higher costs of production. However, makers have their outputs fully sold for some time to come and they are disinclined to make new contracts which specify a fixed date of delivery. Export business has been confined to small tonnages. Prices for home trade are on the basis of 85s. per ton for East Coast mixed numbers delivered in the Middlesbrough area, North-East Coast or Scotland, a rebate of 5s. per ton being allowed to consumers participating in the "loyalty" scheme.

LANCASHIRE.—There has been a marked slackening of activity in this area recently and deliveries of pig-iron during the past month have been on a considerably lower scale than has been the case for many months past. Iron, which has been held in stock at the foundries, is now moving into consumption and this accounts to a large extent for the decline in new transactions. Conditions in the textile-machinery trade remain abnormally slack, while machine-tool makers are well employed, as, also, are works engaged in other sections of the engineering and foundry trade. For delivery to users in the Lancashire price zone offers of Derbyshire, Staffordshire and Lancashire brands of No. 3 foundry iron are on the basis of 83s. per ton, with Northants at 81s. 6d. and Derbyshire forge iron at from 78s. to 80s., according to the class of user. Scottish foundry iron is quoted around 90s. per ton, West Coast hematite at 88s. 6d. and East Coast around 88s., delivered equal to Manchester.

MIDLANDS.—The expected seasonal decline in business in pig-iron has been felt only very mildly in this area and the demand remains on a heavy scale. Stocks generally are very small. Makers are managing to keep pace with the call for supplies, but should any increased demand be made on their outputs, as it is anticipated will occur during the autumn, there is sure to be considerable difficulty in satisfying users' needs. Quotations are unchanged, the current figures delivered Birmingham and Black Country stations for ordinary foundry iron being 77s. 6d. for No. 3 Northants and 80s. for Derbyshire, Lincolnshire and North Staffordshire No. 3, less a small sliding-scale rebate to large consumers. Makers have announced their willingness to enter into business up to March, 1937, and numerous contracts are likely to be made at present quotations. The machine-tool makers and the general engineers are actively engaged and they have heavy requirements of special irons. Prices of such irons are not controlled, but this position is likely to be changed in the near future. Meantime, medium-phosphorus iron is quoted at 82s. 6d. to 90s., low-phosphorus from 92s. 6d. to 100s. (Scottish about 95s.), while refined iron is on offer between £6 10s. and £7 15s. Forge pig-iron is quoted at 5s. per ton below ordinary No. 3 foundry grade, but if required for foundry purposes only 3s. per ton rebate is allowed. The scarcity of supplies of some qualities of hematite is acute and many users are being seriously inconvenienced. West Coast mixed numbers are quoted at £4 17s., East Coast No. 3 £4 16s., and Welsh mixed numbers £4 15s. 6d., delivered local stations, with 1s. 6d. per ton extra if delivered into works. Five shillings per ton rebate on the above prices is allowed to users participating in the "loyalty" scheme.

SCOTLAND.—Most works did not restart after the Fair holidays until Monday, and conditions remain quiet. It is likely that similar conditions will continue to prevail throughout August, this being the holiday month in the south. The decision to place the order for the sister ship to the "Queen Mary" in this district will lead to activity with local heavy industries for many months to come. During the past week business has been on a restricted scale, with prices remaining unaltered at 79s. f.o.t. furnaces for No. 3 foundry, and 2s. 6d. per ton extra for No. 1. No. 3 Cleveland pig-iron is 75s. f.o.t. Falkirk, and 78s. f.o.t. Glasgow, while other English foundry iron is quoted 1s. 3d. per ton less than the foregoing figures. Prices of steelmaking irons are unchanged as follow:—Mixed numbers East Coast, West Coast and Scottish hematite, 85s. 6d., less 5s. rebate; basic, British and Indian, 75s., less 5s. rebate, all delivered steelworks here.

Coke

There is no change to report in the condition of the foundry-coke market, and prices remain very firm. There is no possibility of any reduction in prices being made and many ironfounders are in the market for their requirements over the next half-year, or, in some cases, for a longer period. For delivery in the Birmingham area, best Durham coke is offered at 41s. 6d. per ton and upwards, with other grades down to 39s. 6d., while Welsh coke is quoted from 39s. 6d. (the cheapest) up to 50s.

Steel

There is no slackening in the demand and steelworks remain very active. However, in many cases, there has been enforced stoppages owing to the necessity of carrying out urgent repairs, but generally the holiday was made as short as possible. As a result, deliveries have inevitably fallen further into arrears. It is difficult to transact new business in semi-finished steel owing to the pressure for supplies against existing contracts, and only contracts for forward delivery will usually be entered into. In the finished-steel section conditions are a little quieter, but deliveries are being made on a large scale. Structural steel is well taken up and new business is not easy to arrange. The demand from overseas consumers is heavy, and large quantities have recently been despatched.

Scrap

It is still difficult to dispose of heavy steel scrap in the Cleveland area, most steelworks being well covered. Heavy melting steel remains at 57s. 6d. per ton, while machinery metal is at 67s. 6d., and heavy foundry cast iron 65s., but the demand for the last two named is poor and transactions are being made at lower figures. Quiet conditions continue to prevail in the Midlands area and deliveries have been suspended until after the holidays in some cases. Heavy, unsheared wrought iron receives little support at 65s. to 67s. 6d. Heavy machinery in cupola sizes is at 70s., good heavy pipe and plate at 65s. and clean light at 52s. 6d. to 55s. Short, heavy steel, as used in the foundries, is at 65s. to 67s. 6d. per ton delivered works. Deliveries are on a good scale in the Scottish market and prices remain firm. Heavy steel scrap is at 57s. 6d., while basic, or heavy iron and steel scrap mixed, is 5s. per ton less. Wrought-iron piling scrap is at 69s. to 70s. and special quality is 72s. 6d. to 75s. Heavy machinery cast-iron scrap, in pieces not exceeding 1 cwt., is firm around 68s. 6d. to 70s., while heavy ordinary cast-iron scrap, to the same specification, is around 65s. per ton, delivered f.o.t. consumers' works.

Metals

Copper.—Trading in this country has not been on a very large scale during the past week, but the market has had a good tone for several weeks past. "On Thursday, however, states the weekly report of Rudolf Wolff & Company, "the market suffered a rather sharp reaction on the announcement that the producing interests who were parties to the restriction agreement had decided to lower the percentage of reduction from 30 per cent. to 25 per cent., thereby increasing their output to this extent. This was done with a view to maintaining a better balance of supply and demand, having in mind the recent expansion in consumption and in anticipation that some further improvement in this respect might be anticipated in the next months."

Daily market prices :—

Cash.—Thursday, £37 12s. 6d. to £37 13s. 9d.; Friday, £37 16s. 3d. to £37 17s. 6d.; Tuesday, £38 1s. 3d. to £38 2s. 6d.; Wednesday, £38 to £38 1s. 3d.

Three Months.—Thursday, £37 17s. 6d. to £37 18s. 9d.; Friday, £38 1s. 3d. to £38 2s. 6d.; Tuesday, £38 6s. 3d. to £38 7s. 6d.; Wednesday, £38 6s. 3d. to £38 7s. 6d.

Tin.—The very uncertain position of the tin market gives consumers little encouragement to enter into new contracts and, consequently, the market remains subdued. In the United States buying has been on a fairly good scale. Considerably varying opinions are still being expressed in connection with the future of the restriction scheme, but it would appear that the majority are confident that the scheme will be renewed at the end of the year. According to the statistics issued by Mr. W. H. Gartsen (Henry Rogers, Sons & Company), the total visible supply at the end of July was 13,000 tons, which is a decrease of 348 tons as compared with the end of June. The carry-over in Straits Settlements was 2,142 tons, against 1,673 tons at the end of the previous month, while the carry-over at the Arnhem (Holland) smelter was 822 tons, as compared with 515 tons.

Metal Exchange quotations were as follow :—

Cash.—Thursday, £185 to £186; Friday, £184 15s. to £185; Tuesday, £185 5s. to £185 10s.; Wednesday, £184 5s. to £184 15s.

Three Months.—Thursday, £182 to £182 5s.; Friday, £181 10s. to £182; Tuesday, £182 5s. to £182 10s.; Wednesday, £181 5s. to £181 10s.

Spelter.—There has been a slight decline in the number of inquiries for new business during the past week, but this was to be expected in view of the holiday interruption. Strength has been given to the market by the favourable reports concerning the re-establishment of the Cartel. It is believed that producers are now working for a 10 per cent. cut in smelter production—this, in spite of the fact that the excess output has been held to be very small and the increase in stocks almost negligible. A decline in the rate of zinc production during the month of June is shown by the smelter output figures compiled by the Metallgesellschaft A.-G. Total output is given at 121,192 metric tons, against 126,587 tons in May, and a monthly average of 112,172 tons in 1935.

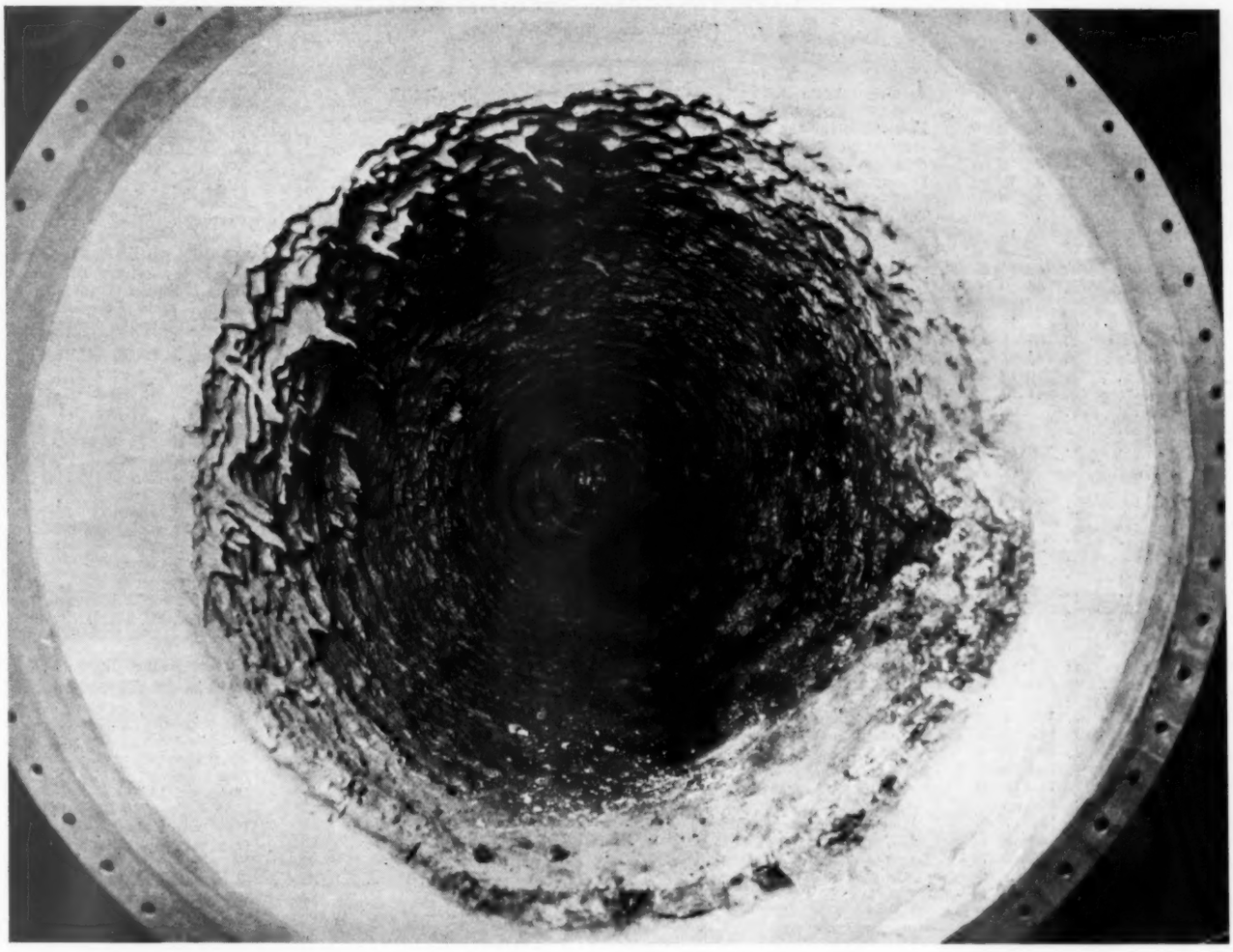
Official quotations were as follow :—

Ordinary.—Thursday, £13 17s. 6d.; Friday, £13 17s. 6d.; Tuesday, £13 17s. 6d.; Wednesday, £13 17s. 6d

Lead.—Firm conditions have continued to prevail in this market and the demand in this country is satisfactory, the building industry being particularly large consumers. According to figures compiled by the American Bureau of Metal Statistics the world production during June was 145,300 short tons, as compared with 144,400 tons in May.

Day-to-day quotations :—

Soft Foreign (prompt).—Thursday, £16 5s.; Friday, £16 15s.; Tuesday, £16 6s. 3d.; Wednesday, £16 8s. 9d.



950 tons of metal melted—

The above photograph shows the condition of an 04 grade Albino lining in a 5-ton Brackelsberg furnace after 255 heats. You will observe the lining has worn dark evenly and it is still approximately 8" in thickness. The 04 grade is specially produced for rotary furnaces, but there are other grades for lining cupolas, converters and ladles.

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RAW MATERIALS—PRICE LIST

(Wednesday, August 5, 1936)

COPPER

	£	s.	d.
Standard cash	38	0	0
Three months	38	6	3
Electrolytic	42	0	0
Tough	40	10	0
Best selected	41	0	0
Sheets	70	0	0
India	50	15	0
Wire bars	42	10	0
Ingot bars	42	10	0
H.C. wire rods	46	0	0
Off. av. cash, July	37	5	0 5/8
Do., 3 mths., July	37	10	10 5/8
Do., Sttlmnt., July	37	5	2 1/2
Do., Electro, July	41	8	7 1/2
Do., B.S., July	40	19	8 1/2
Do., wire bars, July	41	12	8 1/2
Solid drawn tubes			10½d.
Brazed tubes			10½d.
Wire			6½d.

BRASS

Solid drawn tubes	9½d.
Brazed tubes	11½d.
Rods, drawn	8½d.
Rods, extd. or rlld.	5d.
Sheets to 10 w.g.	8d.
Wire	7½d.
Rolled metal	7½d.
Yellow metal rods	5d.
Do. 4 × 4 Squares	5½d.
Do. 4 × 3 Sheets	5½d.

TIN

	£	s.	d.
Standard cash	184	5	0
Three months	181	5	0
English	184	5	0
Bars	185	5	0
Straits	188	15	0
Australian (nom.)		—	
Eastern	184	7	6
Banca (nom.)	187	5	0
Off. av. cash, July	186	4	5 1/3
Do., 3 mths., July	181	1	2½
Do., Sttlmt., July	186	2	9 1/3

SPELTER

	£	s.	d.
Ordinary	13	17	6
Remelted	13	5	0
Hard	11	10	0
Electro 99.9	15	17	6
English	14	17	6
India	12	10	0
Zinc dust	19	10	0
Zinc ashes	4	5	0
Off. aver., July	13	14	0 7/8
Aver. spot, July	13	11	6 1/3

LEAD

	£	s.	d.
Soft foreign ppt.	16	8	9
Empire	17	1	3
English	18	10	0
Off. average, July	15	18	1 3/13
Average spot, July	15	17	1 2/13

ALUMINIUM

Ingots	£100 to £105
Wire	1/3 to 1/4 lb
Sheet and foil	1/2 to 1/4 lb.

ZINC SHEETS, &c.

	£	s.	d.	£	s.	d.
Zinc sheets, English	24	0	0 to	24	10	0
Do., V.M. ex-whse.	24	0	0 to	24	10	0
Rods				26	0	0

ANTIMONY

	£	s.	d.	£	s.	d.
English	64	10	0 to	65	10	0
Chinese, ex-whse.				52	0	0
Crude, c.i.f.				24	10	0

QUICKSILVER

	£	s.	d.	£	s.	d.
Quicksilver	11	12	6 to	12	5	0

FERRO-ALLOYS AND STEEL-MAKING METALS

Ferro-silicon—	
25%	£8 17 6
45/50%	£12 15 0
75%	£17 17 6
Ferro-vanadium—	
35/50%	12/8 lb. Va.
Ferro-molybdenum—	
70/75% carbon-free	4/6 lb. Mo.
Ferro-titanium—	
20/25% carbon-free	9d. lb.
Ferro-phosphorus, 20/25%	£21 to £22
Ferro-tungsten—	
80/85%	3/- lb.
Tungsten metal powder—	
98/99%	3/3 lb.
Ferro-chrome—	
2/4% car.	£33 0 0
4/6% car.	£21 10 0
6/8% car.	£21 0 0
8/10% car.	£21 0 0
Ferro-chrome—	
Max. 2% car.	£33 10 0
Max. 1% car.	£36 5 0
Max. 0.50% car.	£37 5 0
70% carbon-free	9½d. lb.
Nickel—99.5/100%	£200 to £205
"F" nickel shot	£184 0 0
Ferro-cobalt, 98/99%	6/3 to 6/9 lb.
Metallic chromium—	
96/98%	2/5 lb.
Ferro-manganese—	
76/80% loose	£11 5 0 to 11 15 0
76/80% packed	£12 5 0 to 12 15 0
76/80% export	(nom.) £10 5 0
Metallic manganese—	
94/96% carbon-free	1/3 lb.

Per ton unless otherwise stated, basis 2-ton lots.

HIGH-SPEED TOOL STEEL

Finished bars, 14% tungsten	2s. 0d.
Finished bars, 18% tungsten	2s. 9d.

Per lb. net, d/d buyers' works.

Extras—	
Rounds and squares, 3 in. and over	4d. lb.
Rounds and squares, under ½ in. to ¼ in.	3d. lb.
Do., under ¼ in. to 1/16 in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅛ in.	3d. lb.
Do., under ½ in. × ¼ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length, 10% extra.

SCRAP

	£	s.	d.	£	s.	d.
South Wales—						
Heavy steel	3	2	0 to	3	3	0
Mixed iron and steel	2	18	0 to	2	19	0
Heavy cast iron	2	18	0 to	3	0	0
Good machinery	3	2	0 to	3	4	0
Cleveland—						
Heavy steel				2	17	6
Steel turnings				2	0	0
Heavy cast iron				3	5	0
Heavy machinery				3	7	6
Midlands—						
Light cast-iron scrap				2	12	6
Heavy wrought iron	3	5	0 to	3	7	6
Steel turnings				2	0	0
Scotland—						
Heavy steel				2	17	6
Ordinary cast iron				3	5	0
Engineers' turnings				2	2	6
Cast-iron borings				1	17	0
Wrot-iron piling				3	9	6
Heavy machinery	3	8	6 to	3	10	0

London—Merchants' buying prices, delivered yard.

	£	s.	d.
Copper (clean)	29	0	0
Brass	19	0	0
Lead (less usual draft)	14	0	0
Tea lead	9	0	0
Zinc	8	0	0
New aluminium cuttings	74	0	0
Braziery copper	27	0	0
Gunmetal	28	0	0
Hollow pewter	130	0	0
Shaped black pewter	100	0	0

PIG-IRON

N.E. Coast (d/d Tees-side area)—	
Foundry No. 1	77/6
„ No. 3	75/-
„ No. 4	74/-
Forge No. 4	74/-
Hematite No. 1	85/6*
Hematite M/Nos.	85/-*
N.W. Coast—	
Hem. M/Nos. d/d Glas.	85/6*
„ d/d Birm.	97/-*
Malleable iron d/d Birm.	125/-
Midlands (d/d Birmingham dist.)—	
Staffs No. 4 forge	77/-
„ No. 3 fdry.	80/-
Northants forge	74/6
„ fdry. No. 3	77/6
„ fdry. No. 1	80/6
Derbyshire forge	77/-
„ fdry. No. 3	80/-
„ fdry. No. 1	83/-
Scotland—	
Foundry, No. 1, f.o.t.	81/6
„ No. 3, f.o.t.	79/-
Cleveland No. 3, Glasgow	78/-
„ „ Falkirk	75/-
Scottish hem. M/Nos. d/d	85/6*
Sheffield (d/d district)—	
Derby forge	74/6
„ fdry. No. 3	77/6
Lincs forge	74/6
„ fdry. No. 3	77/6
W.C. hematite	91/-*
Lancashire (d/d eq. Man.)—	
Derby fdry. No. 3	83/-
Staffs fdry. No. 3	83/-
Northants fdry. No. 3	81/6
Cleveland fdry. No. 3	83/-
Dalzell, No. 3 (special)	102/6 to 105/-
Glengarnock, No. 3	90/-
Clyde, No. 3	90/-
Monkland, No. 3	90/-
Summerlee, No. 3	90/-
Eglinton, No. 3	90/-
Gartsherrie, No. 3	90/-
Shotts, No. 3	90/-

* Subject to a rebate of 5s. per ton under certain conditions.

FINISHED IRON AND STEEL

Usual district deliveries for iron; delivered consumer's station for steel.

Iron—	£	s.	d.	£	s.	d.
Bars (cr.)				10	2	6
Nut and bolt iron	8	10	0 to	9	0	0
Hoops			11 0 0 and up.			
Marked bars (Staffs) f.o.t.				12	10	0
Gas strip			11 0 0 and up.			
Bolts and nuts, ¼ in. × 4 in.			15 15 0 and up.			
Steel—						
Plates, ship, etc.	9	7	6 to	9	10	0
Boiler plts.	9	17	6 to	10	0	0
Chequer plts.				11	0	0
Angles				9	0	0
Tees				10	0	0
Joists				9	7	6
Rounds and squares, 3 in. to 5½ in.				10	0	0
Rounds under 3 in. to ⅜ in. (Untested)				9	7	0
Flats—8 in. wide and over				9	5	0
„ under 8 in. and over 5 in.				9	10	0
Rails, heavy	8	5	0 to	8	10	0
Fishplates				12	10	0
Hoops (Staffs)				10	2	0
Black sheets, 24g. (4-t. lots)				12	0	0
Galv. cor. shts. („)				14	0	0
Galv. flat shts. („)				14	10	0
Galv. fencing wire, 8g. plain				15	0	0
Billets, soft				6	2	6
Billets, hard	7	2	6 to	7	7	6
Sheet bars				6	0	0
Tin bars				6	0	0

PHOSPHOR BRONZE

	Per lb. basis
Strip	10½d.
Sheet to 10 w.g.	11½d.
Wire	12½d.
Rods	11½d.
Tubes	14d.
Castings	12½d.

Delivery 3cwt. free.
10% phos. cop. £30 above B.S.
15% phos. cop. £35 above B.S.
Phosphor tin (5%) £30 above price of English ingots.
C. CLIFFORD & SON, LIMITED.

NICKEL SILVER &c.

	Per lb.
Ingots for raising	7d. to 1/1
Rolled—	
To 9 in. wide	1/1 to 1/7
To 12 in. wide	1/1½ to 1/7½
To 15 in. wide	1/1½ to 1/7½
To 18 in. wide	1/2 to 1/8
To 21 in. wide	1/2½ to 1/8½
To 25 in. wide	1/3 to 1/9
Ingots for spoons and forks	7d. to 1/3½
Ingots rolled to spoon size	10d. to 1/6½
Wire round—	
to 10g.	1/4½ to 1/11½

with extras according to gauge.
Special 5ths quality turning rods in straight lengths, 1/3½ upwards.

AMERICAN IRON AND STEEL

At Pittsburgh unless otherwise stated.

	Dols.
No. 2 foundry, Phila.	21.31
No. 2 foundry, Valley	19.50
No. 2 foundry, Birm.	15.50
Basic, Valley	19.00
Malleable, Valley	19.50
Grey forge, Valley	19.00
Ferro-mang. 80%, seaboard	75.00
O.-h. rails, h'y, at mill	36.37½
Billets	30.00
Sheet bars	30.00
Wire rods	38.00
	Cents.
Iron bars, Chicago	1.80
Steel bars	1.95
Tank plates	1.90
Beams, etc.	1.90
Skelp, grooved steel	1.80
Steel hoops	1.95
Sheets, black, No. 24	2.50
Sheets, galv., No. 24	3.20
Wire nails	2.10
Plain wire	2.40
Barbed wire, galv.	2.60
Tinplates, 100-lb. box	$5.25

COKE (at ovens)

Welsh foundry	30/- to 31/-
„ furnace	24/6 to 25/-
Durham foundry	24/6
„ furnace	21/6
Scotland, foundry	30/-
„ furnace	25/- to 26/-

TINPLATES

f.o.b. Bristol Channel ports.

I.C. cokes	20×14 per box		18/9
„	28×20	„	37/6
„	20×10	„	26/9 to 27/-
„	18¾×14	„	19/6
C.W.	20×14	„	15/6 to 15/9
„	28×20	„	33/9 to 34/7
„	20×10	„	22/6 to 22/9
„	18¾×14	„	15/3 to 16/-

SWEDISH CHARCOAL IRON & STEEL

Pig-iron	£6 0 0 to £7 0 0
Bars-hammered, basis	£16 0 0 to £16 10 0
Bars and nail-rods, rolled, basis	£15 15 0 to £16 0 0
Blooms	£10 0 0 to £12 0 0
Keg steel	£30 0 0 to £31 0 0
Faggot steel	£18 0 0 to £23 0 0
Bars and rods dead soft, st'l	£10 0 0 to £12 0 0

All per English ton, f.o.b. Gothenburg.
[Subject to an exchange basis of Kr. 18.16 to £1.]

DAILY FLUCTUATIONS

Standard Copper (cash)

	£	s.	d.	
July 30 ..	37	12	6	dec. 6/3
,, 31 ..	37	16	3	inc. 3/9
Aug. 4 ..	38	1	3	,, 5/-
,, 5 ..	38	0	0	dec. 1/3

Standard Tin (cash)

	£	s.	d.	
July 30 ..	185	0	0	inc. 20/-
,, 31 ..	184	15	0	dec. 5/-
Aug. 4 ..	185	5	0	inc. 10/-
,, 5 ..	184	5	0	dec. 20/-

Spelter (ordinary)

	£	s.	d.	
July 30 ..	13	17	6	dec. 3/9
,, 31 ..	13	17	6	No change
Aug. 4 ..	13	17	6	,, ,,
,, 5 ..	13	17	6	,, ,,

Lead (soft foreign, prompt)

	£	s.	d.	
July 30 ..	16	5	0	dec. 3/9
,, 31 ..	16	15	0	inc. 10/-
Aug. 4 ..	16	6	3	dec. 8/9
,, 5 ..	16	8	9	inc. 2/6

Electrolytic Copper

	£	s.	d.	
July 30 ..	41	10	0	dec. 10/-
,, 31 ..	41	15	0	inc. 5/-
Aug. 4 ..	42	0	0	,, 5/-
,, 5 ..	42	0	0	No change

Tin (English ingots)

	£	s.	d.	
July 30 ..	185	10	0	inc. 30/-
,, 31 ..	184	15	0	dec. 15/-
Aug. 4 ..	185	5	0	inc. 10/-
,, 5 ..	184	5	0	dec. 20/-

Spelter (Electro, 99.9 per cent.)

	£	s.	d.	
July 30 ..	15	16	3	dec. 5/-
,, 31 ..	15	16	3	No change
Aug. 4 ..	15	17	6	inc. 1/3
,, 5 ..	15	17	6	No change

Lead (English)

	£	s.	d.	
July 30 ..	18	5	0	dec. 5/-
,, 31 ..	18	10	0	inc. 5/-
Aug. 4 ..	18	10	0	No change
,, 5 ..	18	10	0	,, ,,

AVERAGE MONTHLY PRICES OF RUBIO ORE (MIDDLESBROUGH).

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1897	0 15 3	0 15 6	0 15 3	0 15 0	0 14 0	0 14 3	0 14 3	0 14 0	0 14 0	0 15 0	0 14 3	0 15 3	0 14 8
1898	0 15 0	0 14 4	0 14 9	0 14 6	0 15 0	0 15 0	0 14 0	0 14 0	0 14 0	0 14 9	0 15 0	0 14 9	0 14 7
1899	0 15 0	0 15 3	0 15 6	0 15 6	0 15 9	0 16 0	0 17 6	0 18 0	0 17 9	0 18 0	0 19 0	1 0 0	0 16 11½
1900	1 1 0	1 0 6	1 1 0	1 0 9	1 1 0	1 1 0	1 1 3	1 1 6	1 1 3	1 1 3	1 0 0	0 18 0	1 0 8½
1901	0 17 6	0 16 0	0 15 0	0 14 6	0 15 6	0 15 9	0 14 9	0 15 3	0 15 9	0 15 9	0 15 9	0 15 9	0 15 7½
1902	0 15 6	0 15 0	0 16 0	0 16 0	0 15 6	0 15 3	0 15 6	0 16 0	0 16 0	0 16 0	0 15 9	0 15 6	0 15 8½
1903	0 15 6	0 16 0	0 16 6	0 16 3	0 16 3	0 16 10	0 15 9	0 15 6	0 15 6	0 14 9	0 14 9	0 15 1	0 15 8
1904	0 14 9	0 15 3	0 15 1	0 15 4	0 15 3	0 15 0	0 14 5	0 14 6	0 14 6	0 14 6	0 14 6	0 14 7	0 14 9½
1905	0 15 3	0 15 6	0 15 0	0 15 3	0 15 6	0 15 6	0 15 6	0 15 6	0 16 6	0 18 6	0 18 9	0 18 9	0 16 3½
1906	1 0 0	1 1 6	1 0 0	1 0 0	0 19 6	1 0 0	0 19 6	0 19 4	1 0 6	1 1 6	1 1 9	1 2 8	1 0 7
1907	1 3 6	1 2 6	1 2 6	1 2 0	1 1 6	1 2 3	1 2 3	1 [illegible] 0	1 1 0	0 19 0	0 18 9	0 17 6	1 1 2½
1908	0 16 6	0 15 0	0 15 6	0 15 6	0 15 3	0 15 0	0 15 0	0 14 9	0 15 0	0 16 0	0 16 0	0 16 0	0 15 8½
1909	0 15 9	0 16 3	0 16 0	0 16 0	0 16 3	0 16 6	0 16 0	0 16 0	0 17 0	0 17 0	0 17 6	0 17 6	0 16 6
1910	1 0 4	1 0 9	1 0 9	1 0 9	1 0 9	1 0 9	1 0 9	1 0 3	1 0 3	1 0 6½	1 1 3	1 1 5	1 0 9½
1911	1 2 2½	1 2 6	1 2 6	1 1 11½	1 11½	0 19 6	0 19 0	0 19 0	0 19 1½	0 19 6	1 0 0½	1 1 6½	1 0 7½
1912	1 2 3	1 2 6	1 2 6	1 1 1½	1 1 6	1 1 6	1 1 6	1 2 3	1 2 6	1 3 0	1 3 0	1 2 11	1 2 3½
1913	1 2 9	1 2 2	1 1 7½	1 1 6	1 0 8½	1 0 0	1 0 0	1 0 0	0 19 10½	0 19 1½	0 19 0	0 19 0	1 0 3½
1914	0 18 7½	0 18 0	0 18 0	0 17 9	0 17 6	0 17 6	0 17 1½	0 19 7½	0 18 11½	0 17 10½	0 18 7½	1 1 0½	0 18 8½
1915	1 7 7½	1 8 6	1 9 3	1 10 2½	1 8 6	1 6 4	1 5 10½	1 6 0	1 6 10½	1 10 8½	1 13 0	1 17 10	1 9 1½
1916	1 18 6	2 0 1½	2 2 6½	2 0 6½	1 15 0	1 16 2	1 18 0	1 18 0	1 18 0	—	—	—	—
1917	} Price Fixed												
1918													
1919	—	—	—	—	2 5 7½	2 14 4½	2 16 4½	2 14 0	2 13 4½	2 13 0	2 12 7½	2 11 9	—
1920	2 17 0	3 7 9	2 15 6	3 6 7	3 0 0	2 15 0	2 14 0	2 9 9	2 7 6	2 11 0	2 12 3	2 10 0	2 15 0
1921	2 1 0	2 0 1½	1 18 3	1 17 6	1 17 6	1 17 6	1 17 6	1 5 0	1 8 9½	1 7 9	1 7 0	1 7 0	1 13 8½
1922	1 6 7½	1 5 10½	1 6 11	1 7 0	1 7 0	1 7 0	1 5 3	1 4 9½	1 4 2½	1 3 3½	1 2 6	1 2 3	1 5 2½
1923	1 2 9½	1 4 6½	1 5 2	1 4 8½	1 4 6	1 4 0	1 3 6	1 3 0	1 3 0	1 3 0	1 3 2½	1 4 9	1 3 10½
1924	1 4 2½	1 4 0	1 4 0	1 3 7½	1 3 8½	1 3 6	1 2 11	1 2 6	1 2 1½	1 1 7½	1 2 3	1 2 6	1 3 1
1925	1 2 6	1 2 1½	1 2 0	1 2 0	1 2 0	1 1 6	1 0 6	1 0 0	1 0 0	1 0 0	1 0 3	1 0 10½	1 1 1½
1926	1 1 1½	1 1 6	1 1 6	1 1 3½	1 1 3	1 1 5½	1 1 6	1 1 6	1 1 0	1 1 6	1 1 6	—	1 1 4½
1927	1 2 1½	1 2 3	1 2 1½	1 2 0	1 2 0	1 2 0	1 1 7½	1 1 0	1 1 0	1 1 0	1 1 0	1 1 0	1 1 7½
1928	1 1 0	1 1 1½	1 1 11	1 2 4½	1 2 6	1 2 6	1 2 6	1 2 6	1 2 6	1 2 6	1 2 6	1 2 6	1 2 2½
1929	1 2 6	1 2 6½	1 2 11½	1 3 0	1 3 0	1 3 2½	1 4 0	1 4 8½	1 4 7½	1 4 6	1 4 6	1 4 3	1 3 7½
1930	1 3 3½	1 2 6	1 1 9	1 1 6	1 0 10½	1 0 0	1 0 0	0 19 6	0 19 0	0 17 4½	0 16 4½	0 16 4½	0 19 10½
1931	0 16 1½	0 16 0	0 16 0	0 15 11½	0 15 4½	0 15 0	0 14 10½	0 14 3½	0 14 6	0 16 8½	0 17 0½	0 16 6	0 15 9
1932	0 16 6	0 16 6	0 16 3	0 15 6	0 15 4½	0 15 0	0 14 11	0 14 8½	0 14 6	0 14 6	0 14 9	0 15 1	0 15 3½
1933	0 15 6	0 15 3	0 15 3	0 15 3	0 15 3	0 15 6	0 15 6	0 15 6	0 15 6	0 15 11½	0 16 6	0 16 6	0 15 7½
1934	0 16 6	0 17 6	0 16 9	0 16 6½	0 16 8½	0 16 9½	0 17 0	0 17 0	0 17 0	0 17 0	0 17 0	0 17 0	0 16 10½
1935	0 17 0	0 17 4½	0 17 6	0 17 6	0 17 6	0 17 6	0 17 6	0 17 6	0 17 6	0 17 7½	0 18 0	0 18 0	0 17 6½
1936	0 18 0	0 18 3½	0 18 6½	0 18 9	0 18 9	0 19 0½	1 0 0	—	—	—	—	—	—

WILLIAM JACKS & COMPANY,

WINCHESTER HOUSE, OLD BROAD ST., LONDON, E.C.2.

CLARENCE CHAMBERS, 39, CORPORATION STREET, BIRMINGHAM.

13, RUMFORD STREET, LIVERPOOL.

PIG IRON

REGISTERED TRADE MARK

LIMPET

FOR EVERY TYPE OF CASTING

NON-FERROUS METALS

REFRACTORIES — COKE — SAND

FERRO-SILICON—FERRO-CHROME

WILLIAM JACKS & COMPANY,

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ZETLAND ROAD, MIDDLESBROUGH.

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(A remittance should accompany instructions.)

SITUATIONS VACANT AND WANTED

SINGLE Man, aged 30, with experience of ironmongery trade, seeks situation in this line; any district. Excellent references.—Write W. GAMBRILL, 64, George Street, Reading, Berks.

AN Engineer Assistant with good office experience wanted for India. Age about 30. Knowledge of general foundry trade and mill work. Salary about Rs. 800 per month with free unfurnished quarters. 4½ years' engagement. Applications stating age, experience, etc., to "BIHAR," c/o Advertising Department, 5, New Bridge Street, London, E.C.4.

WANTED.—Representative for sales and service. Special core oils and core compounds.—Box 828, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

EMPLOYMENT REGISTER.

Conducted by the Institute of British Foundrymen by courtesy of the proprietors of THE FOUNDRY TRADE JOURNAL.

Correspondence should be addressed to the General Secretary, Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester, from whom full particulars can be obtained of this service.

Any employer wishing to communicate with a candidate should write to the General Secretary, quoting identification number.

FOUNDRY Manager requires position or as Assistant. Young, practical moulder, excellent experience in managerial positions on general engineering and also repetition work. Cupola control. Sound technical training. (281)

MANAGER, age 40, practically and metallurgically highly qualified Engineer with 15 years' experience in large iron, steel, brass and aluminium foundries, desires responsible position with well reputed firm. (282)

IRONFOUNDRY Foreman desires position with progressive firm. Experienced in jobbing work, machine moulding, general engineering, estimating, cupola practice, etc. (283

BUSINESS FOR SALE

IRON FOUNDRY.—Well equipped and recently modernised, situated in the heart of an industrial area in the West Riding of Yorkshire, with a capacity of 30/40 tons per week. An appreciable volume of business is guaranteed, and the proposition is an attractive one to the right people. Inspection invited.—Box 830, Offices of THE FOUNDRY TRADE JOURNAL, 49, Wellington Street, Strand, London, W.C.2.

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